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SALT-RANGE FOSSILS.

Vol. IV, Part 2.

GEOLOGICAL RESULTS.

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PLATES I—VIII.

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BIBLIOTHECA
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A.—LOWER PALÆOZOIC SERIES.

1. Purple Sandstone Group.

Strictly speaking, this group of rocks does not come within the scope of the present work, because in the entire set of sub-divisions of which it is composed not a single fossil has been found up to the present. Nevertheless, for the sake of completeness, and because it appears indispensable for the thorough understanding of the super-imposed rock-groups, I shall make a few remarks on it, though I shall be as brief as possible.

The sub-divisions within this group are as follows, from above downward :—

Upper Purple Sandstone (Purple Sandstone of Wynne).
Rock-salt and red gypsum group.
Grey gypsum group.
Lower Purple Sandstone.

It has been stated above in the description of the single groups that this succession is open to some doubt; but the reasons have also been given why the succession as stated appears the more probable one.

Taken as a whole, the prevalent rocks of this group are dry-looking, mostly fine-grained purple sandstones, among which brick red and grey marls, red and grey gypsum and beds of rock-salt are intercalated.

The sandstones above and below the gypseous groups are very similar, though apparently not absolutely identical. Conglomerates are, however, in both cases completely absent, rolled pebbles of about the size of a walnut being the largest that are sometimes met with, and even these are rare.

The upper purple sandstone is rather shaly in its lower portion. The colour is very uniform throughout; only in the topmost portion sometimes lighter tints, chiefly yellow ones, occur. Ripple-marks are present but not too frequent: besides these, "obscure and doubtful traces of fucoids" or worm tracks are observable off and on.

The lower purple sandstone is described on page 71 of Wynne's Trans-Indus report as "dry-looking, purple, red, and whitish sandstones" of 250 to 300 feet thickness. Red (in opposition to purple) and whitish rocks are barely known at all in the Cis-Indus upper purple sandstones, and thus a certain difference seems to exist.

If we try to find equivalents for the present purple sandstone group in other parts of the world, we must leave out of consideration the occurrence of rock-salt and gypsum; as these rocks are necessarily of a more or less local distribution, their formation being dependent on the existence, in the vicinity, of a series of isolated basins, to which the sea has only a very limited access, and from which fresh water is shut off entirely.

Thus, the chief rock on which we can rely for comparisons are the purple sandstones. If we look out, before all in India, for rocks which can in any way be

compared to the purple sandstones of the Salt-range, we find that in the Himalayas no such rocks can be found in lower palæozoic situations. On the other hand, rocks of a similar description are largely developed in peninsular India, where they have been classed under the name of Vindhians.

Among the Vindhians, it is again chiefly the upper division, which to a certain extent recalls these purple sandstones: and one might be inclined to look out for the real equivalents of the latter among the Rewah and Bhanrer groups.

It is well known that the Vindhians, properly speaking, rest "with little or no unconformity" upon a lower group of rocks, which has formerly received different names, but which has all been comprised, in the Manual of the Geology of India, as Lower Vindhians. Where these latter are absent, which is not very rarely the case, there exists a great unconformity between the Upper Vindhians and the transition beds of the Arvali series, or the still older gneissic rocks.

This criterion of unconformable deposition upon older rocks cannot be applied in the Salt-range, as the basal rocks of the purple sandstone group are nowhere exposed to view. That, however, also here, the transition rocks of the Arvali series are not very far distant is proved by the existence of the Korana hills, where, at a distance of not more than forty miles to the south of the Salt-range, rocks which belong according to all authorities to the Arvali series, compose the greatest part of the ground. These quartzites and slates dip to the north, but are in their strike apparently a little deviating from the strike of the Salt-range; so that the possibility of the existence of an unconformity is not absolutely excluded.

The nearest point with regard to the Salt-range where rocks, with some probability belonging to the Vindhians, have been observed is in the country of Jodhpur, west of the Arvali-range. The rocks there are coarse sandstones of a dull red colour, occasionally also white or brown. Pebbles occur occasionally in them, but the rock is barely ever conglomeratic. The first discoverer of these beds was W. T. Blanford. Later on, they have again been visited by Mr. R. D. Oldham, but doubts as to their Vindhian age have been put forth by him (Rec. Geol. Surv. Ind., Vol. XXI, p. 32, 33); so that it seems, not much reliance can be put on the fact of Vindhians occuring west of the Arvali-range, as a point of comparison of the Salt-range rocks with those of peninsular India.

On the whole, we may say that it is not quite improbable that the purple sandstone group might be correlated in a general way with the Upper Vindhians of peninsular India; though there are no decisive proofs in this respect. Some further points of probability with regard to a correlation of the two series will be adduced in the sequence.

To institute any comparison of the purple sandstone with beds in more distant countries seems absolutely useless; especially where there is such entire absence of fossils. At the same time, however, the relations of the purple sandstone to the next higher fossiliferous horizon furnish some points of similarity with beds occurring in China; and thus indirectly it may be possible to follow up the probable equivalents of the purple sandstone group also in more distant regions.

2. Magnesian Sandstone Group.

The Magnesian sandstone group is composed of the following sub-divisions, from above downward :—

3. Red shaly zone (Salt-crystal pseudomorph zone of Wynne).
2. Magnesian sandstone.
1. Dark shaly zone (Neobolus beds).

I have comprised these sub-divisions in one group on account of the rather intimate stratigraphical relations that seem to exist between these single members. Nevertheless, I am not quite sure, whether I am right in so doing, since it has now been proved that several concealed discordances exist in the Salt-range, which, though unobservable in the single sections, are yet apparent in considering larger tracts of ground. I am, therefore, by no means sure, whether such may not also creep in between these single members; and whether beds which appear most intimately connected in single sections may not be really separable by long intervals of time.

The most important of these sub-divisions from a palæontological point of view is the dark shaly zone, or the *Neobolus beds*, though, geologically speaking, they are not very conspicuous, forming only more or less a lower shaly portion of the Magnesian sandstone. It is to these beds that I would now more particularly direct the attention of the reader.

a. *Dark shaly zone* (*Neobolus beds*).

Ascending from below upwards in the series of formations of which the Salt-range is composed, the present one is the first in which fossils have been found in great numbers, though only belonging to a few species.

The demarcation of the sub-group is not very easily drawn, though its lower limit against the purple sandstones of the preceding group is somewhat better defined than the upper one towards the magnesian sandstone. The prevalent rocks are mostly dark, more or less micaceous shales between which sandstones, mostly of a greenish tint, which are very often glauconitic and sometimes somewhat calcareous, are intercalated. Ferruginous beds also occur. The sandstones generally predominate in the upper region, and thus a kind of transition is established towards the Magnesian sandstone.

The fossils collected by Mr. Wynne and myself all came from the dark shales near the base of the group, not far above the purple sandstone. The greenish, mostly glauconitic, sandstones higher up proved at most localities unfossiliferous; and only at a single place, at Chél hill, Mr. Wynne collected a small fragment of rock, of which he was, however, doubtful whether it had come from the Magnesian sandstone or from the upper region of the dark shaly zone, and which contained specimens of *Hyolithes wynnei*. I myself was prevented by severe illness from visiting that locality; but this omission has been made good by Dr. Warth, who searched

that and several other adjacent localities upon my instigation, and with what results we shall see in the sequence.

For the moment, we return to the dark shales at the base of the group. The fossils collected in these beds by Mr. Wynne, Dr. Warth, and myself, are the following :—

Discinolepis granulata, W.
Schizopholis rugosa, W.
Neobolus warthi, W.
„ *wynnei*, W.
Lakhmina linguloides, W. sp.
„ *squama*, W. sp.
Lingula kiurensis, W.
„ *warthi*, W.
Fenestella, sp. indet.

All these fossils, with the exception of the last, are brachiopoda, and all of them have shells of a horny calcareous nature. Not less than five families are represented among them and these are: the *Discinidæ*, the *Siphonotretidæ*, the *Obolidæ*, the *Trimerellidæ* and the *Lingulidæ*.

This association would very strongly suggest a Cambrian age for the beds: nevertheless, I did not accept such an interpretation for several reasons.

Before all, the *Fenestella* does not fit into this society; nor does it into cambrian beds. Though its generic determination is by no means certain, the form is, at any rate, a very extraordinary one in lower cambrian strata. As far as my experience goes, the genus *Fenestella* does not appear before the upper region of the lower silurian. But even if the fossil should prove in time not to be a *Bryozoon* at all, but some *Hydrozoon*, it could only be placed in the vicinity of *Dictyonema* or the like, which also do not make their appearance before the upper silurian. Thus the occurrence of such a fossil in this society is under all circumstances a very exceptional one and tending to throw doubt on the geological relations of the bed in which it occurs.

Taking the brachiopoda next into consideration, we find that, though the families to which the single forms belong, are all such as we are accustomed to find in cambrian strata, yet the genera are all different. That the generic differences have not been instituted by me at random, but are really thorough and well founded cannot well be doubted; and, as a surety for this, Mr. Davidson's opinion can be adduced, who in a letter advised me to make new genera out of all these things, as they were not like anything he had seen from cambrian beds.

Thus there remains only the identity of the families. To found, however, on such family-similarities geological conclusions has generally proved a very precarious thing. To adduce only a single example in this respect, I may be allowed to recall to the mind of the reader the dispute that once arose with regard to the fossiliferous beds exposed on the east coast of South Africa, in the vicinity of the

Sunday river, &c. Founded on a general similarity of the fossils there collected to species occurring in the lower Oolite of England, the age of these beds had been pronounced as lower oolitic; and it will yet be well remembered how this determination was used also for fixing the age of certain fossiliferous beds in India. That all this has been fallacious, has been proved conclusively by Professor Neumayr's more recent investigations which have shown these South African beds to be Neocomian. This is only one example of how little reliance can be placed on general similarities for the geological identification of certain deposits, and such could be augmented by hundreds. In general, one can say that nothing is more unsafe than to correlate beds in distant countries, except on the identification of a number of rigorously determined species.

How much the more had I to be cautious as there were not only no species identical with cambrian ones, but even all the genera were different with the exception of the cosmopolitan genus *Lingula*.

On this came the geological conditions under which the fauna apparently occurred. When I came to the Salt-range I was instructed in the Indian mode of travelling with a camp by Mr. Wynne, and went with him rather cursorily over the eastern part of the range up to Pail, where he left me. My intention had been, when returning from Kalabagh, to examine these eastern parts of the range more closely and at leisure, but when actually returning I was so very ill that my observations were very limited, and many of the sections that I had yet wished to examine had to be left untouched. So I had to rely for the eastern parts of the range on the few observations I had made during my cursory visit, and chiefly on the descriptions of Mr. Wynne, whom I had, however, always found to be a very fair observer. From all this, I gathered as a final conclusion that there existed no great break in the succession of rock-groups in the Salt-range, but that one seemed to follow rather regularly above the other, except at the base of the Nummulitics, where a great unconformity seemed to exist. But even this was strongly protested against by Mr. Wynne, and the mode in which he criticized my deviating opinion will yet be remembered by some of my readers.

Now the Neobolus fauna had been found a few hundred feet below typical permian beds; while the existence of any break was most emphatically denied by Mr. Wynne, I myself also not having sufficiently distinctly observed such. Was it not then absolutely unintelligible, from a geological point of view, how beds in such proximity to the permian could possibly be cambrian, without a break between? The fauna gave no decided evidence; for, though the families were cambrian, the genera and species were all new. Was it not, under such circumstances, more probable that cambrian types, under changed forms, had survived by some favourable circumstances into the carboniferous period, to which I was led to attribute the beds on geological grounds?

Thus, I came to describe the fauna of the Neobolus beds as of carboniferous age.

Notwithstanding all this, my conclusions have not been borne out by the later

discovered facts. First of all, the general concordance of the single rock groups was found not to exist in reality; and later on, Dr. Warth detected even an undoubtedly cambrian fauna in beds very little higher in the sequence than the Neobolus beds. But if, then, these beds are really cambrian, and this fact cannot be doubted any longer; how can it be explained, that nevertheless the fauna so far deviates from the faunæ detected in other countries in beds of a similar geological age?

This question cannot be solved very easily; and before entering on this discussion it will be necessary to take a glance at the fossils that have been found by Dr. Warth in the vicinity of Chél hill.

This little fauna, consisting of not more than six or seven species, was found in the beds with *hyolithes wynnei*, W., and seems to hold a geological position in the upper region of the dark shaly zone, in the glauconitic and strongly felspathic sandstones that form the transition to the Magnesian sandstone. The most remarkable things among the whole lot are several fragments of Trilobites, some of which are clearly determinable, whilst others cannot be determined. These trilobites, as far as they can be determined, are decidedly cambrian forms; and as trilobites furnish by far the safest indications for the determination of the age of the beds, in which they occur, there cannot be any doubt that these beds are of cambrian age.

Besides the Trilobites, there occur some Pteropods and Brachiopods. The species are as follows:—

TRILOBITÆ.

Family: *CONOCEPHALIDÆ.*

Genus: CONOCEPHALITES, Barr.

1. Conocephalites warthi, Waagen, n. sp., Pl. I, fig. 1, *a. b.*

The specimen that serves for description consists of the central parts of a head without the free cheeks. It is rather small, not more than 4 mm. in length, and more or less trapezoidal in its general outline. The anterior margin is considerably shorter than the posterior one; the greater length of the latter is, however, chiefly due to the protraction of the posterior lateral corners.

The glabella is strongly convex, slightly conical in shape and rounded in front, surrounded on all sides by a deep dorsal impression, by which it is marked off from the cheeks and the anterior part of the head. There are three pairs of lateral furrows on the glabella. The first or posterior pair is deepest and most strongly marked, each furrow being, however, not simple but bifid, beginning simple in the depth of the dorsal impression, and then becoming divided, one branch extending towards the occipital furrow, the other running straight up towards the middle of the glabella, without, however, reaching both.

The second, or median, pair is about as strongly marked as the first one, but it is

somewhat shorter, according to the less considerable breadth of the glabella at this place. It is but very little directed backward. The third or anterior pair is also well marked but very short. All these furrows reach up only about one-third of the entire breadth of the glabella, whilst the median third remains free and smooth.

The occipital or neck-ring is strongly developed. It is of about equal breadth up to where it approaches the dorsal impressions, where it suddenly becomes narrow and disappears. It bears no trace of a tubercle in the middle. On its anterior side it is limited by a deep occipital furrow, that is narrowest in the middle and gets somewhat broader towards the dorsal impressions. Posteriorly the occipital ring is limited also by a deep furrow, that again is hemmed in by a low rim, that was covered, in the living state, by the first thoracic segment.

The part in front of the glabella is comparatively narrow, occupying not more than one-fourth of the entire length of the head. It is marked off from the glabella by the deep dorsal impression bending here round, and from the fixed cheeks by low straight ridges that extend from the anterior end of the glabella towards the eyes in a somewhat sloping direction. The anterior margin of the head forms a regular low arch, and is strongly bent up forming a high rim. Behind this, there is a broad deep impression, following the same direction and extending to near the origin of the glabella.

The fixed cheeks are well vaulted, but much lower than the glabella. Anteriorly they bear the low ridges that separate the frontal part from the cheeks properly speaking, and this ridge unites laterally with a low rim that surrounds the recess in which the eyes have been located. On the posterior end of the cheeks there extends a deep furrow along the posterior margin, which latter is not quite straight but first, beginning at the dorsal impression, slightly descending, and then at the corner suddenly bent up.

The facial suture converges slightly from both sides from the anterior margin down to the eye; there it is cut out in a concave curve, and then it descends with an outward direction very obliquely in a convex arch to the posterior corner. Thus the specimen is narrowest just where the eyes are situated, and broadest at the posterior margin.

The measurements are as follow :—

Entire length of the specimen	4 mm.
Length of the glabella	3 „
Breadth at the anterior margin	4·5 „
„ „ „ posterior margin	7 „
„ of the glabella at the occipital ring	2·25 „
„ „ „ „ „ „ anterior end	2 „
Distance of the posterior corner from the dorsal impression	3 „
„ „ „ eye „ „ „ „	1·75 „

Locality and Geological position.—The only specimen of this species that has come under my notice was collected at Chél hill in somewhat nodular sandy shales, the fossils being preserved as little concretions, in the upper region of the *Neobolus*

beds.* Very numerous specimens of *Hyolithes wynnei*, W., and a number of specimens of a little *orthis* have apparently been found in the same bed.

Remarks.—There are several remarks to be made with regard to the present species. Before all, it must be explained why I have used the name *Conocephalites* for its generic designation. There are several names in use for similar forms, and in many cases it is very difficult to decide which of them ought to be used. In many cases the employment of one of these generic names is chiefly dependent on the number of thoracic segments present or on the development of the pygidium, as in *Crepicephalus* according to Mr. Walcott's definition. When, however, only the head is available for description, such genera must be excluded from the beginning.

Mr. C. D. Walcott, in his excellent papers on the Cambrian faunas of North America, accepts three genera for the forms more or less nearly related to what has generally been called *Conocephalites*, these are: *Conocoryphe*, Corda, *Ptychoparia*, Corda, and *Anomocare*, Angelin. The first comprises the forms without eyes, the second those with eyes and a moderately developed anterior margin, and the third those with eyes and an enormously developed anterior margin. According to Barrande's definition of the genus *Conocephalites*, it ought to comprise those forms that have received from Corda the name of *Conocoryphe* as well as those that have been called *Ptychoparia* by the same author. By the greater part of geologists, however, the name *Conocephalites* has been employed in the sense of *Ptychoparia*, so that *Conocephalites* and *Ptychoparia* would be synonyms. In such a case, however, I prefer Barrande's name, though it was actually published at a later date; as it is well known how Corda managed to bring his names more quickly to the notice of the public than it was possible for M. Barrande to do with the publication of his large volume.

Just as it is easy in such a manner, to distinguish between *Conocoryphe* and *Conocephalites*; so is it difficult to distinguish between the latter and *Anomocare*. It is a matter of degree what forms ought to be attributed to the one or the other genus, and thus it must be left to the taste of each author how far they are inclined to extend the limits of the one or the other genus. Mr. C. D. Walcott has limited the name *Anomocare* to those forms which have the part between the anterior end of the glabella and the anterior margin developed in a quite extraordinary degree; whilst Prof. Dames restricts the name *Conocephalites*, as far as I am able to deduce from his figures and descriptions, to those species which have the same part only quite narrow. I am rather inclined to follow Mr. Walcott's example, as the greater part of the species that have been described by Angelin under the name *Anomocare* have the anterior part developed in an excessive manner.

Thus I have described also the present form as *Conocephalites*. As to species;

* All Dr. Warth could say concerning the localization of his find was, that he afterwards detected a trilobite-like form in the collection he brought away with him; that is, that it came somewhere from the Neobolus beds. He told me this when I visited him at Dehra regarding his collection of these fossils: so that as far as Dr. Waagen knew, the actual position of the trilobite was not so clear as he would here imply.—Ed.

there is quite a number of them, to which the present one appears to be more or less nearly related. The one in which the greatest similarity seems to exist is *Conocephalites formosus*, Hartt, as figured by Walcott, which species is, however, considered by the latter author as identical with *Conocephalites* or *Ptychoparia robbi*, Hartt. The differences between the two forms, the Indian and the American, are small, but yet sufficient, I think, to distinguish the two as different species. The most striking difference consists in the direction of the facial sutures, which in the Indian species are deeply cut out in the region of the eyes and again strongly project towards the posterior corner, whilst they form a generally sloping line from the anterior to the posterior margin in *Conoc. formosus* as well as in *Conoc. robbi*. Another point of difference consists in the bifid condition of the first pair of lateral furrows on the glabella in *Conoc. warthi*, whilst the same part of the sculpture is simple in the American forms.

With regard to this latter character, however, the Indian species resembles a cambrian trilobite that has been described by Prof. Dames from China under the name of *Conocephalites quadriceps*, Dam. But though in this respect a resemblance exists, in other points the two species deviate rather far from each other. The anterior margin is by far narrower in the Chinese species, the eyes are quite differently placed, and also the cheeks are differently vaulted.

Yet a closer relation, amounting nearly to identity, exists between our *Conoc. warthi* and *Solenopleura cristata*, Linnarsson, from the Paradoxides beds of Sweden only; the anterior margin is somewhat broader, and the first pair of furrows on the glabella is not bifid in the European form. I think, however, with regard to these, though small differences, and to the enormous geographical distance, it will be more prudent to regard the two as different species.

To give further points of comparison with other species seems unnecessary. On the whole, it may be said that similar forms exist only in cambrian beds, whilst in more recent formations similar forms are much more rare or entirely absent.

Family: *OLENIDÆ*.

Genus: OLENUS, Dahn.

2. OLENUS INDICUS, Waagen, n. sp., Pl. I, fig. 3 *a*. *b*.

The specimen that serves for description is too fragmentary and too badly preserved to allow of an exact generic determination. As, however, these few cambrian fossils that have been detected in India are of such an overwhelming interest, I do not think it superfluous to notice and describe even such badly preserved things, so much the more when they bear such striking characters as the present specimen.

The glabella and part of one of the fixed cheeks are alone preserved in the specimen at disposal.

The glabella is 5 mm. in length and is very strongly vaulted. It has a distinctly conical shape, being much narrower in front than at the base. It is surrounded by a deep dorsal impression, which is rather broad, as the fixed cheeks ascend only slowly. Its anterior part is narrowly rounded, whilst the sides are tolerably straight but sloping. There are two pairs of lateral furrows distinctly visible, of which the posterior forms deep impressions on both sides of the glabella and then ascends, slightly directed backwards, up to the vaulted part of the glabella, where the furrows from both sides unite, being, however, here much shallower than at the sides. The second or anterior pair is also very distinctly marked at its beginning at the dorsal impression. They run up straightly, becoming at the same time quickly shallower, but, nevertheless, they can be followed as a faint impression up to the middle of the glabella, where they unite from both sides.

The anterior or frontal margin is not preserved, but a narrow smooth space extends in front of the glabella, as the remainder of the frontal part.

Of the fixed cheeks, only very little can be seen. A broad oblique fold runs from the anterior end of the glabella to the lateral margin at the end of which the eye probably was situated, but otherwise nothing can be seen.

An occipital furrow and neck-ring can also not be observed; but their existence is, on the whole, probable.

The most remarkable feature of the whole specimen, however, is its surface sculpturing which consists of countless pointed warts and tubercles very irregularly arranged and of very unequal size. Only the depth of the dorsal impression and the little bit of the frontal part that is preserved appear to be smooth.

The measurements of the specimen are as follows :—

Entire length of the specimen	6·5 mm.
Length of the glabella	5 „
Entire breadth of the specimen as far as preserved	8·5 „
Breadth of the glabella at the base	5·25 „
„ „ „ „ „ the anterior end	3 „

Locality and geological position.—The specimen was collected by Dr. Warth in a glauconitic felspathic sandstone at Kussak, evidently in the upper region of the *Neobolus beds*. In the same rock are preserved fragments that belong to a horny-shelled brachiopod, also specimens of a smooth *Hyolithes* and two little spines, probably of trilobites, that will be treated of presently.

Remarks.—Though so badly preserved and fragmentary, the present specimen is still of very high interest. Whetner it may be really an *Olenus* must remain doubtful. The circumstance that the furrows reach distinctly across the glabella seem to me to indicate such an affinity. It is true, that the genus *Ptychaspis* could also have been compared, but here the furrows are more strongly marked. On the whole, the specimen seems to point rather to an upper cambrian than to a lower cambrian affinity.

TRILOBITES GEN. ET. SP INDET., Pl. I, fig. 2 *a. b.*, fig. 4 *a. b.*, fig. 5 *a.*—*d.*, fig. 6.

There are numbers of small fragments which evidently are of trilobites, but which cannot be determined either generically or specifically. Nevertheless, I thought them worth mentioning, as the materials are so scanty, and the existence of cambrian beds in India of such importance, that even such small fragments are not without interest.

These fragments can be divided into two sets. First, there are a number of broad flattened spines, evidently the posterior terminations of free cheeks, as they occur in most of the *Conocephalidæ*. Some of them point to rather large forms, as the longest and best preserved is not less than 12mm. in length, though still incomplete, and 3mm. in breadth at the upper end. The broadest fragment points even to a still larger individual, as it is not less than 5mm. in breadth.

Several of these spines show in an excellent manner the wavy lines (Pl. I, fig. 4) that are mostly exhibited on the interior side of the shell of *Paradoxides* and other genera. Free cheeks, which also occur (Pl. I, fig. 2), might belong to *Conocephalites*.

All these specimens were found in the nodular shales with *Conocephalites warthi*.

Quite different things occur not rarely in the felspathic sandstones in which *Olenus indicus* has been detected. These are slender, rounded spines (Pl. I, fig. 6), of sometimes not inconsiderable length. Some of them are curved, some straight. They strongly recall the slender spines that are borne on the free cheeks of *Sphærophthalmus*, or by the pygidium and the pleura of *Ctenopyge*.

Class: GASTEROPODA.

Order: CONULARIDA.

Family: *THECIDÆ.*

Genus: HYOLITHES, Eichw.

HYOLITHES WYNNEI, Waagen, Pl. I. fig. 7—10. *Vide ante*, vol. I, p. 781 (1885).

At the time of description of the present species, there were not more than two tolerably well preserved specimens known to me, which had been collected by Mr. Wynne at Chél hill in beds of a somewhat doubtful geological position. Nevertheless, these two little things have proved to be of the utmost importance, as they were the cause of my suggestion to Dr. Warth that he should search the localities around Chél hill for further fossils.

The hundreds of specimens of this species, collected by Dr. Warth, have not furnished many new characters which should be added to the description already

published. They only show, that the size of the species is always very moderate, and seems never to exceed 15mm. in length.

The apical angle of the shell varies somewhat, even sometimes in one and the same individual, and then in such a case the lateral outlines appear somewhat crooked. Generally, it is not more than 17 to 17½ degrees, but sometimes it is even as little as 12°.

The apex is often bent somewhat backward, towards the flattened posterior side, and in such cases this latter is always more or less strongly excavated in the apical region.

The most striking character of the species consists in the distinct furrow that extends longitudinally in the middle of the anterior or vaulted face, a character that approaches the present species more or less to *Conularia*, and which would be quite sufficient to found a new genus on it. In exceptionally well preserved specimens, one sees sharp lines of growth, that are tolerably strongly bent up, where they reach the median furrow. Towards both sides they descend in a gentle curve to be again slightly elevated towards the lateral angles. On the posterior side they form a strong arch directed towards the front, which projects considerably further than the anterior side.

These striæ of growth indicate also the shape of the apertural margin, which is not preserved in any of the specimens. They are most strongly developed and most easily visible in the vicinity of the anterior furrow, where, in exceptionally well preserved specimens, they form a kind of crenulation on the ridges by which the furrow is hemmed in on both sides, which is extremely similar to the sculpture of *Conularia* as developed in analogous places of the shell.

Also, the posterior face of our *Hyolithes wynnei* is not always only provided with the striæ of growth; but sometimes we find also here some faint longitudinal furrows and ridges, mostly two in number (lateral ones) and very rarely three (one median). It needs, however, an exceptionally favourable preservation, in order that this kind of sculpture should be visible.

Nothing like an operculum has as yet been observed in the specimens at my disposal.

The measurements of two specimens are as follow:—

	I.	II.
Entire length of the shell	14 mm.	17 mm.
Thickness at the upper end from side to side	5 „	5 „
„ „ from back to front	3 „	3·25 „
Apical angle	16°	10°

Locality and geological position.—The species seems to be extremely numerous in the higher divisions of the Neobolus beds, whilst it has not yet been observed in the beds with *Neobolus warthi* as exposed at Kiura or Intana.

It was collected by Warth at numerous localities from Chél hill up to near Kiura. The species seems to occupy a bed of nodular blackish shale, and occurs there associated with *Conocephalites warthi*.

Remarks.—There is no species to which the present one can be compared. The numerous forms of *Hyolithes* that have been described out of cambrian beds by Walcott, Hall, &c., are all without a median furrow on the anterior part, and thus bear not the slightest similarity.

HYOLITHES KUSSAKENSIS, Waagen, n. sp., Pl. I, fig. 6, fig. 11*a*—*c*.

There is only a single specimen of this species among the materials collected by Dr. Warth, and even this is not very well preserved; but, as the Indian cambrian fauna is of so very great interest in general, it seems to me that the occurrence of a second species of *Hyolithes* ought to be noted down.

The species is again of very small dimensions. Its transversal section is triangular, the two lateral angles being rather acute, the median one rather rounded. The posterior face is flattened or slightly excavated, of the three the broadest. The two anterior facets are slightly vaulted and much narrower, uniting in the middle under a rounded angle, without showing any trace of a median furrow like the preceding species.

The surface is without any sculpture.

The whole shell is slowly tapering towards the apex, which comprises an angle of about 16°.

The measurements are as follow:—

Entire length of the shell about	8 mm.
Diameter at upper end from side to side	3 „
„ „ „ „ from back to front	1·75 „
Apical angle	16°

Locality and geological position.—This species was collected in the glauconitic sandstones in which *Olenus indicus* is also preserved.

On the same rock fragments containing the specimen of *Hyolithes kussakensis* are numerous fragments of those slender spines which probably once belonged to trilobites of the type of *Ctenopyge* or the like.

Remarks.—There is quite a number of species of *Hyolithes* in cambrian beds, with which the present form seems to be more or less closely related.

The species that shows the greatest similarity is *Hyolithes primordialis*, Hall, from the Potsdam Sandstone; but the anterior angle of that species is much more strongly rounded and less prominent; the size is also more considerable.

Of other species, perhaps *Hyolithes communis*, Bill., might be compared, but also here, very striking differences exist. Before all, the shell is very thick in the American species, in which respect it resembles much more *Salterella* than *Hyolithes*; while the transverse section shows all the angles more or less strongly rounded, which is not the case in the Indian form. Also *Hyolithes socialis*, Linnarsson, from the *Paradoxides* beds of Sweden, is not dissimilar in its size as well as in the general outline; but here also the anterior angle is somewhat more rounded and the apical angle somewhat smaller.

It therefore seems to me, that the present species, though represented only by a single specimen, can be considered as a well distinguishable form.

Class: BRACHIOPODA.

Order: ARTHROPOMATA.

Sub-order: APHANEROPEGMATA, *sive* Productacea.

Family: *ORTHIDÆ*.

Genus: ORTHIS, Dahn.

ORTHIS WARTHI, Waagen, n. sp., Pl. I, fig. 12—15, Pl. II, fig. 1, 2.

The little things that serve for description have rather puzzled me for some time, as there is no trace of the shell preserved. They are much compressed and deformed; while any preparation was out of the question, as the specimens are softer than the rock in which they are preserved.

On the whole, however, it is most probable that it is a species of *Orthis* which is represented, and I shall do my best to describe it as accurately as possible.

The species is of moderate size, not more than 10^{mm}. in each direction. The valves are apparently not much vaulted, though this is difficult to state on account of the deformation the specimens have undergone by pressure. On the whole, the species appears to be more or less lenticular.

Of the two valves the one is larger, the other smaller, though the difference is not very considerable. I take the larger to be the ventral, the smaller the dorsal valve; though I am by no means certain in this respect.

The frontal margin is straight, without a sinus, the hinge-line short, considerably shorter than the greatest breadth of the shell.

The larger (ventral ?) valve is most strongly inflated in the apical region and more or less flattened towards the margins. The apical region appears even as if slightly carinated. It terminates in a pointed distinctly curved-over beak, below which a very wide triangular deltidial fissure is observable. This fissure is placed in the middle of a well-developed distinct concave area of tolerable height. At both sides of the deltidial fissure the cast shows sharp, prominent ridges, extending from the apex to the hinge-margin, at the end of which ridges probably the hinge-teeth were situated.

As no trace of a shell is present, the internal casts show the muscular impressions tolerably clearly: it is, however, not easy to interpret them rightly. There is a group of such impressions directly below the apex from which and from the margins of the area it is limited off by a low furrow. This group occupies about one-third of the entire length of the shell. At the lower end of it two deep furrows develop, corresponding to strong ridges in the shell, which slightly diverge towards the

frontal margin, and occupy the second third of the entire length of the shell. Between these, there is a second group of muscular impressions, which is, however, too indistinct for recognition of sub-divisions within it. This latter group of impressions is narrow and elongate, whilst the upper group is roundish. It seems to me that all these impressions will probably correspond to the adductor muscles; the lower elongate impression to a lower pair of adductors, the upper roundish impression to an upper pair. The divaricators were probably inserted along the ridges by which the lower median impression is hemmed in on both sides.

The space outside these muscular scars is perfectly smooth, no traces of vascular impressions being visible.

The smaller (dorsal ?) valve is much flatter than the other one. The apex is not very prominent and the area narrow, though this latter is not well exposed in any of the specimens; so that I cannot state with certainty whether a deltidial fissure has been present or not. In the internal casts, which alone are available for description, the apex appears flattened and somewhat bent up. It is separated from the rest of the shell by deep furrows, which correspond probably to the shelly plates upon which the crura were supported. From the apex there extends a deep, gradually widening, impression over the greater part of the shell to near the frontal margin. The upper part of this impression apparently served for the insertion of a pair of muscles, whilst another pair of scars is situated just outside the impression, occupying here irregularly oval, or somewhat triangular, sightly raised spaces. All these scars evidently belong to the two pairs of adductors.

It appears not possible to give measurements of the present species, as all the specimens are deformed and broken to a degree. The dimensions can be gathered in a general way from the figures on Pl. I and II.

Locality and geological position.—Quite a number of specimens were collected by Dr. Warth at different localities between Chél hill and Kiura. The species occurs in the upper region of the Neobolus beds together with *Conocephalites warthi;* and, in fact, the specimen of that species that has been described on the foregoing pages is attached to a specimen of the present one. *Hyolithes wynnei* also belongs to the same horizon.

Remarks.—Though numbers of species belonging to the genus *Orthis* have been described up to the present out of cambrian beds, yet there are apparently very few things to which the present form offers a close comparison. As the internal casts of our *Orth. warthi* are entirely smooth, showing no traces of a radial plication, the external sculpture of these shells can have been only a fine radial striation; and thus we must look out among the finely striated forms for relations of the present species. Among these *Orthis pepina*, Hall, from the Potsdam Sandstone, must be considered in the first line. Though, however, a general resemblance between the American and Indian shells cannot be denied, yet it is very easy to distinguish the two, *Orthis pepina* having a much longer hinge-line, and much stronger developed ridges and shelly plates in the apical region than our *Orthis warthi*.

Of other species, none seems to be more intimately connected with the Indian

form, except perhaps *Orthis lindströmi*, Linnarss., from the *Paradoxides*-beds of Sweden; but this species becomes larger and the internal cast is much more strongly sculptured.

To recapitulate what has been stated on the preceding pages, we have the following species out of the different rocks:

a. Out of the glauconitic sandstones:

Olenus (?) *indicus*, W.
Trilobites, gen. et sp. indet.
Hyolithes kussakensis, W.

b. Out of the dark concretionary shales:

Conocephalites warthi, W.
Trilobites, gen. et sp. indet.
Hyolithes wynnei, W.
Orthis warthi, W.

Small as the number of different forms is, several conclusions may be drawn from them.

First of all, as far as can be concluded from these things, it seems that the two rocks contain absolutely different faunas, not a single species being identical.

The forms out of the glauconitic sandstones furnish in *Olenus* (*?*) *indicus* a species which can only, to a certain extent, be used for the purpose of comparison with the cambrian faunas of other countries. As far as can be judged from the rather badly preserved specimen, its affinities seem to be rather upper than lower cambrian, according to the distinctions generally used now. Also, the slender spines of *trilobites* detected in the same rock point rather to upper cambrian forms. The *Hyolithes kussakensis* is not in contradiction with the above, as it can be compared to *Hyolithes communis*, out of the cambrian Potsdam sandstone. All these indications must, however, be taken solely for what they are worth; as simple tentatives, to unriddle the question of the exact age of the Indian cambrian beds, and not as real definitive conclusions.

The same is the case with regard to the opinions that I may venture to put forward with regard to the contents of the black nodular shales. The most important species for comparison is again the trilobite *Conocephalites warthi*. The genus *Conocephalites* is well represented in the upper cambrian, as well as in the lower, but the specific affinities of the Indian species are decidedly lower cambrian. *Ptychoparia formosa* or *robbi*, as well as *Solenopleura cristata*, the two forms with which the Indian one is most intimately connected, are lower cambrian species and occur in the *Paradoxides*-beds of America and Sweden, respectively.

The other fragments of trilobite shells, the broad flattened spines, are not in contradiction with such a parallelisation, as these spines might even be as well fragments of heads of *Paradoxides*.

Hyolithes wynnei is a quite isolated form and cannot serve for any conclusion;

and *Orthis warthi* is as well related to upper cambrian as to lower cambrian species.

From all this it appears that the glauconitic sandstones may, perhaps, in time, turn out to be equivalents of the upper cambrian; whilst the nodular shales may either fall within the horizon of the *Paradoxides* beds, or else they may be at the limit between upper and lower cambrian.

So far all is square, but now the difficulties commence. The Neobolus-shales, which contain all these interesting brachiopoda, are probably on a yet lower horizon than the nodular shales with *Hyolithes wynnei*, for Mr. Wynne, on p. 145 of his Salt-range report, says in a footnote: "These fossils being very obscure, and possibly belonging to detached upper beds of the Obolus or Siphonotreta-zone"—(if not to the Magnesian sandstone, as stated in the text). But already, the beds with *Hyolithes wynnei* are probably the equivalents of the *Paradoxides* stage: on what horizon must then the Neobolus shales be placed?

In Europe the next lower horizon, below the *Paradoxides* beds, is characterised by the genus *Olenellus*, although besides a number of other trilobites very few other fossils have been found. In opposition to this, in America, the beds with *Olenellus* have formerly been stated to hold a position above the *Paradoxides* beds; and according to Mr. Walcott the genus *Olenellus* was considered to characterise there the middle cambrian. The fauna is there considerably richer than in Sweden and quite a number of sponges, Graptolites, Cystidea, Brachiopoda, Bivalves and Gasteropods are described in Mr. Walcott's excellent monograph, besides the numerous Trilobites. Most recently, however, Mr. Walcott has published a paper in the American Journal of Science, in which he states that also in America the position of the genus *Olenellus* is probably the same as that assigned to it in Europe; so that the rich fauna contained in these beds would hold the lowest horizon within the cambrian system.

Which of the two views taken in the matter is the right one I am not in a position to decide; while the fauna of the Neobolus shales gives no clue whatever in this respect. The only similarity I can find seems to exist between one of the valves of *Lingulella ella*, Hall, and my *Davidsonella* (more rightly called *Lakhmina* by *Öhlert*); but as the interior of the other valve of the American species is apparently entirely different, all comparison ceases. *Lingulella ella* is a species of the *Olenellus* beds of western North-America.

Thus we are left entirely to our imagination, when bent on the determination of the exact age of the Neobolus shales; and the possibility is not excluded, that these beds are lower in their position within the cambrian series, than any of the fossiliferous beds that have been described up to the present. Perhaps the strangeness of the fauna may be explained in such a way, rather than, as I have formerly done, by accepting a more recent age for these strange things.

Most recently, Dr. King has sent me the drawing of the head of a trilobite, which latter had been found by Mr. Middlemiss at Kussak peak in beds above the brachiopoda strata of the Neobolus beds.

This drawing represents most distinctly the head of an *Olenellus*, and is therefore of the greatest importance. From this, it appears highly probable that the nodular shales above the brachiopoda beds contain also yet the *Olenellus*-fauna.

The succession of the faunæ within the Cambrian system would thus, with some probability, be as follows :—

4. *Olenus*-fauna.
3. *Paradoxides*-fauna.
2. *Olenellus*-fauna.
1. *Neobolus*-fauna.

After thus having tried to fix, as far as it has been possible, the age of the cambrian beds of the Salt-range, we can proceed to look out for equivalents of these beds in other countries.

It is well known that no cambrian beds have been detected up to quite recent times elsewhere in India, the lowest beds that have furnished fossils in the Himalaya being of lower silurian age. Only, in a most recent paper in the Records, Mr. Griesbach identifies certain beds in Spiti and Gurhwal as cambrian. The fossils that have been found in these strata seem, however, to be rather badly preserved and few in number.

The nearest country where cambrian beds with numerous fossils are known to exist, since some time, is China, where Baron von Richthofen collected a well characterised cambrian fauna. These fossils have been described in detail by Prof. Dames in Vol. IV of Richthofen's work. The specimens have all been found in the upper region of an extensive formation, that has received the name of Sinic formation from Baron Richthofen. The existence of this formation has first been fixed by Richthofen in Lian-tung, not far from the frontier of Korea; and then the same formation has been followed by him through the provinces of Lian-hsi, Shantung, Tochili, Shansi, and Honan.

In general, the formation consists of two members between which a slight discordance seems to exist. The lower member consists of dark red or purple soft sandstones which always rest directly on granite or crystalline schists,—then of quartzitic sandstones and conglomerates, interbedded with softer sandy argillaceous strata of generally more light tints, but also often red. The entire lower member has at least a thickness of 2,000 feet.

The upper member is more shaly or marly in its general composition. The marls are of a red or green colour, and interbedded with soft sandstones of similar tints. Within these shaly beds, several groups of limestone layers exist which have been separated into two sets, a lower one, consisting chiefly of siliceous limestones named by Richthofen Tungwoun beds, and an upper one, more purely calcareous, often globulitic and charged with much glauconite which he called the Lungmoun limestones. The entire upper marly member has a thickness of at least 5,000 feet.

The cambrian fauna, which has been described by Dames and Kayser, has been collected solely in the globulitic limestones of the Lungmoun series. The fauna of

the two chief localities (Saima-ki and Ta-ling) consists of about 16 species of trilbiotes of the genera *Conocephalites*, *Anomocare*, *Liostracus*, and *Agnostus* and three species of brachiopoda: one of *Orthis* and two of *Lingulella*. None of the species is identical with any form described from other countries, but the whole character of the fauna is decidedly cambrian. Dames, in discussing the relations of the fauna, comes to the conclusion that it corresponds most closely with that of the beds with *Paradoxides forchhammeri* or the Andrarum-Kalk of Sweden, the topmost division of the lower cambrian.

At another locality, Wulo-pu, a slightly different fauna has been detected. It consists solely of trilobites of the genera *Dorypyge* n. gen., *Anomocare* and *Liostracus*; and Dames thinks that this fauna indicates a somewhat higher horizon, and parallelizes it with the Quebec group of Utah or the *Ceratopyge* limestone of Sweden (Tremadoe); that is to say, with beds which either must be considered as forming the topmost division of the cambrian or else the lowest division of the silurian.

If we now compare these results obtained by Prof. Dames by the study of those Chinese fossils with what has been said by me with regard to the cambrian fossils of the Salt-range, it will be seen that we both very nearly agree in our conclusions. For the glauconitic felspathic sandstones with *Olenus*, I accepted a probably upper cambrian age; whilst for the nodular marls with *Hyolithes wynnei*, a lower cambrian age seemed to be more probable. My conclusions were, however, necessarily less concise than those of Prof. Dames as the materials at my disposal were also much more limited. On the whole, it seems most probable that the horizons occupied by the Chinese cambrian faunas are not very much different in age from those exposed in the Salt-range, though these latter perhaps comprise a more extensive series of beds; and that thus the Neobolus beds of the Salt-range form part of what has been called in China "Sinic formation" by Richthofen.

This Sinic formation not only comprises, however, the globulitic limestones containing the cambrian fauna, but it has been extended to yet much lower horizons, which partly, as the Tungwoun beds, form yet part of its upper member, whilst sandstones of mostly a red colour compose the lower member. If we compare this assemblage of beds with the sequence of formations as they are exposed in the Salt-range, a striking similarity between the two rock series cannot be denied. In both countries: below, a series of red sandstones, and above these a cambrian fauna of a similar composition: such a similarity cannot be accidental, but the two might safely be considered as identical at least in a homotaxial sense, if not contemporaneous. But then also the purple sandstone group of the Salt-range must be considered as corresponding to some part of the Sinic formation.

As, however, the purple sandstone most probably corresponds to the Vindhian system of peninsular India; also, for the latter a certain homotaxis with the Sinic formation becomes highly probable, so much the more as the composition of the Upper Vindhian system is not dissimilar to that of the mentioned formation. In the Sinic formation conglomerates are of frequent occurrence in the lower region,

red sandstones aud shales predominate in the middle, and in the upper divisions strong limestones are intercalated between the shales and sandstones. Quite the same is the case in the Upper Vindhians; and though this similarity cannot be taken as a decisive proof for the identity, which proof would alone be furnished by trilobites being found in the limestones, yet it goes far to make such an identity highly probable.

This is all that I am able to say with regard to the probable equivalents of the dark shaly zone (Neobolus beds) and its allies to the formations as developed in other countries. My indications are, I regret to say, very vague and uncertain, but to say more (as long as more extensive materials, collected exactly according to single geological horizons, are not available) would transgress the limits of safe geological reasoning.

b. *Magnesian sandstone.*

Much more uncertain however must be my indications about the group of rocks that follows next above the dark shaly zone, to which Wynne has given the name of Magnesian sandstone.

The petrographical characters of the rock can easily be gathered from Mr. Wynne's descriptions in Vol. XIV of the Memoirs. In the easternmost parts of the range, the rock attains a considerable thickness and is very conspicuous in the outlines of the hills, as it is at the same time very compact and might be rather styled a sandy dolomite, or simply a dolomite, than a magnesian sandstone. But this condition does not last very long. Towards the west, it quickly loses its hard compact character, and appears more or less as a light-coloured mostly greenish sandstone, which is not easily separable either from the sandstones of the dark shaly zone below, or from the sandstones of the speckled sandstone group above.

Even Mr. Wynne, though such an acute observer generally, seems to have been mistaken in this respect in some cases, as is evident from a section in the Nila-Wán which he published on page 190 of his Salt-range report. Though this section, as stated by him, is chiefly taken from my own notes, yet it is not reproduced exactly as I have taken it down; for Mr. Wynne has introduced some changes which do not exactly correspond to what I have observed in nature. I should not insist upon my section being absolutely right, as Mr. Wynne probably had his reasons for correcting my views; but in the meantime Dr. Warth also visited the section, and his observations are identical with my own. These remarks apply chiefly to that part of the section before which Mr. Wynne has placed the Nos. 3 and 4. My note-book gives this part of the section as follows:—

No.	18.—Lavender-clay, very dark in colour	10	feet.
„	19.—Red sandstone with many alternations of red and darkly purple shale, about	80	„
„	20.—Green sandstone with a bed of boulders at the base	60	„
„	21.—Purple sandstone	200	„
	22.—Purple shales	2	„

According to these notes, any member replacing the Magnesian sandstone or the Neobolus-beds is entirely absent, and the boulder bed of the speckled sandstone group rests here directly and unconformably on the purple sandstone.

Absolutely the same observation has been made by Dr. Warth, who in the Records (Vol. XX, p. 117) says—"Inside of the gorge the strata observed were the purple sandstone, then the boulder bed, above that greenish sandstone, then very thick beds of the red sandstone (Wynne's "Speckled") overlaid by lavender-clays and more recent beds. Near the mouth of the gorge there was also seen a remnant of the Magnesian Sandstone, 10 feet below the boulder bed, recognised by the peculiar lenticular markings described by Wynne at pages 88 and 153 in the Salt-range Memoir. About 50 feet lower the Neobolus shales were also recognised by the minute white shells which Mr. Wynne first discovered in them at other places. The position of the boulder bed at the base of Wynne's speckled sandstone is thus quite undoubted."

Mr. Wynne here evidently mistook the green sandstones and conglomerates as Magnesian sandstone, and added to these the true magnesian sandstone and the Neobolus beds he had observed further down stream towards the mouth of the gorge.

It is well to remember that Mr. Wynne's indications in this particular point are not absolutely certain, as the only fossil that was collected by him in the Magnesian sandstone would fit much better into the Speckled sandstone than into the present group.

This fossil is the *Sigmodus dubius*, W. described in Vol. I of the present work.

The relations of this fossil are such that even its position in lower carboniferous beds, considered by me to be the age of the Magnesian sandstone, was somewhat extraordinary. In this respect this fossil was one of the strongest inducements for my considering these and the next following lower beds as not older than carboniferous.

This specimen was the only fishtooth, preserved in a sandstone, contained in the Salt-range collection; and though Mr. Wynne in seeing the worked out fossil, doubted its being his specimen, yet it was the only one to which his remark on the occurrence of fishteeth in the Magnesian sandstone could have referred; moreover, a label to this effect was attached to the fossil. The small plant fragments mentioned in the same passage were probably the specimens of *Hyolithes wynnei* from Chél hill also contained in the Salt-range collection.

Now, however, after the cambrian age of the Neobolus beds has been proved beyond doubt, the possibility of the occurrence of such a tooth as *Sigmodus* is in the Magnesian sandstone is very nearly excluded. Only then it would be explainable if we accept again a great unconformity and break of deposition between the Neobolus beds and the Magnesian sandstone; so that the latter would be of much more recent age. For such a supposition, however, not the slightest indication has been found up to the present; on the contrary, the Neobolus beds seem to pass slowly by intercalation of sandstones into the Magnesian sandstone.

Thus, there seem two possibilities:—

(1) Either there has not been any mistake about the *Sigmodus dubius*, the only fossil recorded as occurring in the Magnesian sandstone; in which case this group of rocks cannot be in any way older than devonian at the utmost, and there must be a break in the sequence between the Neobolus-beds and the Magnesian sandstone. Or else,

(2) The Magnesian sandstone follows directly and in uninterrupted sequence above the Neobolus beds; when it must correspond in age either with the topmost cambrian or the lowest silurian: and thus the probability of the *Sigmodus dubius* having been found really in this geological position is but very small. Much more probable is it that some mistake anyhow, either a change of labels which is the more probable thing, or in the moment of collecting it, has occurred with regard to this specimen; so that it must be referred to some other formation, perhaps to the speckled sandstone.

I must confess that the second view seems to me by far the more probable one, and thus I am inclined to attribute to the Magnesian sandstone either an upper cambrian or else a lower silurian age.

To look out for equivalents of this group of rocks in other parts of the world seems rather hopeless, as in the face of the absence of fossils but very few characters remain which can serve for comparison. Its close relation to the Neobolus-beds may, perhaps, be used for a comparison of the Magnesian sandstone with the limestones of the Sinic formation, or the calcareous part of the Vindhians; chiefly as red beds follow again above it. To say, however, more in this respect seems not prudent.

c. *Red shaly zone.*

The great difficulties which had to be encountered with regard to settling the age of this group are well displayed in Wynne's Salt-range memoir. I myself have seen this group at only a few places; and in the face of the absence of any trace of fossils and the vagueness of the geological facts relating to these beds, I was, as well as Wynne, at a loss how to classify these beds. The petrographical similarity to certain of the Keuper beds of Germany at last induced me to propose a triassic age for these strata.

Now, after it has been proved that the boulder-beds of the speckled sandstone group are super-imposed on the red shales; there can be no more thought of a triassic age for these beds, as they certainly form part of the lower palæozoic series.

These red shales and sandstone flags with the salt-crystal pseudomorphs on the bedding planes—are without doubt an æstuarine deposit. I have formerly expressed the opinion that it was at the mouth of a large river, where these beds have been formed; and even now, though many of the premises upon which I had based

that opinion have proved in the meantime to be fallacious, I am not averse to such a view, as the distribution of these beds is so capricious and so limited that one is nearly forced to suppose that they have been deposited under quite peculiar circumstances.

Mr. Wynne has arrived at quite similar results; and he gave expression to them on page 101 of his Salt-range report.

Another very difficult question with regard to these beds is, whether they ought to be considered as belonging to the same sequence of rocks as the Magnesian sandstone. There is no doubt that the physical conditions under which the red shales have been deposited were considerably different from those prevailing during the deposition of the Magnesian sandstone. Such a change in the physical conditions might easily involve a break in the sequence of formations, if it is not dependent on local differences, as I have formerly supposed.

It must therefore remain doubtful, whether we may rightly include the Red Shaly zone in the Magnesian Sandstone group; and it may easily happen that, in the future, direct proofs may be found that such should not be done. As it is, however, with regard to the complete absence of any kind of fossils, it is impossible to decide the question; and the only indication upon which we can rely being the position of the Red shaly zone below the boulder beds of the speckled sandstone, I cannot do any thing but consider this zone as forming part of the lower palæozoic series, including it in a provisional way in the Magnesian Sandstone group.

With regard to a parallelisation of these beds with the deposits in other countries, we are in the same position as we were with regard to the Magnesian sandstone. The petrographical characters recall again to a certain extent those of the Sinic formation, or of the Upper Vindhians; but one cannot be by any means certain whether these are not altogether misleading. As long as palæontological indications are absent we may, however, be justified in following the petrographical similarities, and consider also this Red shaly zone as homotaxially equivalent to one of the topmost members of the Sinic series, or of the Vindhian system.

If we now reconsider all that has been said about the Lower Palæozoic series of the Salt-range; we see that, on the whole, it is barely probable that it must be divided into several formations, but all forming one great complex of beds, which, for a part at least, can be parallelised with certainty with the cambrian system of Europe.

With regard to Peninsular India; it corresponds with some probability in a general way to the Upper Vindhian system, and with regard to China to the Sinic formation of Richthofen.

The beds of rock-salt, exposed in the Salt-range, are on a lower level than any of the rock-salt deposits hitherto recorded; being lower in the series than the lower cambrian. Thus Dr. T. Oldham's views on the matter, which he expressed as far back as 1873 at the Vienna Exhibition, have been borne out wonderfully by the newly ascertained facts, though they had been obscured for a time by a wrong interpretation of the fossils, and by a misunderstanding of the geological features.

B.—UPPER PALÆOZOIC SERIES.

1. Speckled Sandstone Group.

It has already been stated in the Introduction to the present volume that it is extremely difficult to indicate general characters for this group, as its aspect in different localities changes so very much that scarcely any particular bed can be followed for great distances. Only large sub-divisions can be retained; and I have proposed to distinguish as such: a lower division as Boulder beds, a middle division as Middle Speckled Sandstone, and an upper division as Upper Speckled Sandstone or Lower Productus-limestone.

To give a general idea of the composition of the whole group, it will be best to start with a section measured by me in the Nila-Wán, where the three sub-divisions are easily distinguishable.

The section runs as follows:—

? *Cardita beaumonti* beds.	7.	Debris, covering the section for a thickness of about 20 feet at the base of the nummulitic series	
	8.	Dark green, thickly bedded sandstones with grains of pisolitic iron ore and large *Nautili*, small bivalves, a gigantic *Conus* (all internal casts), and at last some spines of *Cidaris*	15 feet.
	9.	Bed richer in iron and nearly entirely pisolitic, blackish-brown . .	5—6 ,,
	10.	Very irregular layer of dark coloured, somewhat coaly shales, with some appearance of discordance with the lower following strata, about	6 ,,
Upper Speckled Sandstone (Lower Productus-limestone).	11.	Coarse sandstone, light yellowish grey with many fossils, the shells of which are greatly weathered, mostly leaving the specimens as internal casts: *Marginifera sp.*, *Dybowskiella*, *sp.* indistinct bivalves .	10 ,,
	12.	Coaly sandy shale	10 ,,
	13.	Light greenish sandstones, with some coaly intercalations and a few undeterminable fossils, one bed of the sandstone being 20 feet thick .	50 ,,
Middle Speckled Sandstone.	14.	Lavender clay	6 ,,
	15.	Greyish and blackish shales, with many rather closely-set indurated marl-beds	60 ,,
	16.	Lavender clay and thick white and yellowish sandstone interstratified	100 ,,
	17.	A bed of red sandstone, about	30 ,,
	18.	Lavender clay, very darkly coloured	10 ,,
	19.	Red sandstone, with many alternations of red and purple shale . .	80 ,,
Lower Speckled Sandstone (Boulder beds).	20.	Green sandstone, rather soft, with some crystalline pebbles . .	60 ,,
	20*a*.	Bed of crystalline boulders, with rare sandy calcareous nodules containing specimens of *Conularia*, *Serpulites*, &c.	1½ ,,*
		Unconformity.	
Purple Sandstone Group.	21.	Purple sandstone	200 feet.
	22.	Purple shale	

* This bed has been separated from No. 20 on the ground of Dr. Warth's observations. In my note-book it is united with No. 20.

The brackets in this section show not only that here the three sub-divisions of the speckled sandstone group cannot be distinguished, but also that they follow perfectly regularly one above the other without any appearance of discordance or unconformity; whilst the whole group itself is unconformable to the lower strata. At the upper limit of the group follows again a bed which shows some signs of discordance. What age ought to be attributed to this bed which bears the number ten in the section, remains doubtful. It might perhaps form part of the variegated jurassic group. The *Cardita beaumonti* beds, which follow yet higher in the section, are well characterised, and some of the casts of small bivalves mentioned might be *Cardita beaumonti* itself.

All three sub-divisions, as represented in the above section, are of a sandy nature; and were there no fossils, it would be difficult to make any distinctions within the group. This character, however, does not last long in any direction. The upper division disappears very soon to the east of the present section altogether, and to the west it becomes more and more calcareous, though sandstones are also here never entirely absent. The middle division is the most constant one and forms also the bulk of what has been called "Speckled Sandstone" by Mr. Wynne. The red sandstones are mostly very conspicuous; the lavender clays in the upper region also mostly present. The lower division is the most variable of all; and we shall see in the sequence that many doubts have been raised as to its representation at different parts of the range.

As regards the fossils contained in the group, it can be said that they are very irregularly distributed. Up to very lately, fossils were known to exist in greater numbers only in the upper division, which circumstance caused me to consider this division to be rather more connected with the super-imposed limestones than with the sandstones below. The geological relations of the beds to each other are the same above and below, and it is evident that there was no break in the deposition and sequence of the beds. The fossils of these beds, however, after they have been studied in detail, show certain peculiarities which indicate that a distinguishing boundary should be drawn between the beds composing the upper division of the speckled sandstone and the limestones above; and thus I have become doubtful whether these strata should not rather be called "Upper Speckled Sandstone" instead of "Lower Productus-limestone," as I have done formerly.

The middle division has not, so far, furnished any undoubted traces of fossils. A block of brown sandstone was, however, found by Dr. Warth in the foundations of a tumble-down hut, which contained several specimens of a *Spirifer*. Though brown sandstones are not of common occurrence in this region, such are mentioned by Mr. Wynne at several localities, and it is therefore not quite improbable that the block found by Mr. Warth came from the middle region of the speckled sandstone or else from the upper beds of the lower division of the same formation. Though this is a very vague indication, it leads to the conclusion that there are still fossiliferous beds to be detected in the speckled sandstone of the Salt-range which have up to the present escaped the attention of the different observers.

At the time I visited the Salt-range, nobody would have dreamed of distinguishing the lower division of the speckled sandstone on palæontological grounds; and it is entirely due to the assiduous investigations of Dr. H. Warth that such is possible now. Though the fossils found in this division are not very numerous, they are so much the more of interest, as they show many points of affinity to the carboniferous fauna of Australia. Whether these fossils are to be considered as occurring *in situ*, or as being found in a secondary position, is a question which will be treated later on in the text. This lower division is also of especial interest, in as much as in many localities it shows traces of glacial action.

To discuss the palæontological characters of the group, as a whole, is of no use, as the two faunæ which are known to exist up to the present, in the upper and in the lower divisions, show but little affinity to each other, and thus each must be treated separately.

(a). Lower Speckled Sandstone, Boulder Beds.

There are two characters which chiefly distinguish the present sub-division: these are, first, the occurrence of boulder beds which contain glacially striated pebbles; and second, the occurrence of nodules or concretions with remains of *Conulariæ* and other fossils.

These characters have, however, only been slowly recognised. The first one is but little apparent, and it was chiefly the occurrence of immense blocks of crystalline rocks which caused the observers to undertake a close search for glacially striated pebbles. But even after these had been detected, this detection was not worth very much, as it was impossible with the data then available to fix the exact age of these strata.

The only fossils which have been described in Volume I out of these beds were the few things that had been collected by Mr. Wynne at Saiduwali, Trans-Indus. The species are the following:—

Hyolithes orientalis, Waagen.
,, *sp. indet.*
Cardiomorpha indica, Waagen.

Of these, the two first are very indistinct things, the generic position of which is even not quite certain. The third, however, is of some geological importance as its relations are thoroughly carboniferous.

The species were found by Mr. Wynne in black shales exposed at the base of a great boulder conglomerate which was found to contain glacially striated pebbles.

This was all that was known up to a few years since of the age of the Trans-Indus boulder beds. Whether the boulder beds that were known to be developed in the Cis-Indus part of the Salt-range were to be considered as identical in age with those Trans-Indus, and also belonging to the carboniferous period, remained quite doubtful.

Certain characters have, however, been lately detected by Dr. Warth which have gone far to elucidate the relations between the boulder beds exposed in the different parts of the Salt-range, and which make it at least highly probable that all the boulder beds should be considered as belonging to one and the same group of rocks. These characters consist in the occurrence of concretions and pebbles with *Conulariæ* and other fossils which have proved to be distributed over a large surface in the boulder beds of the Eastern Salt-range. The fossils contained in the concretions are also all carboniferous types, as will be shown later on.

If we then, according to the guide thus obtained, consider all the glacial boulder beds of the Salt-range as belonging to one and the same group, we can distinguish three different types of development of the group in different parts of the range. The most extensive development of the group occurs in the Trans-Indus part of the range. There the group attains locally a thickness of over 500 feet, and it is composed, according to a section of the Kingriáli cliffs taken from Mr. Wynne's Trans-Indus Report, as follows:—

Upper Productus-limestone.		15. Bellerophon sandstone and Dentalium beds.
Middle Productus-limestone.		14. Strong cliff-limestones.
Speckled Sandstone group.	Lower Productus-limestone, Upper Speckled Sandstone.	13. Sandy limestone with terebratulæ and corals. Thick splintery magnesian layers without fossils.
		12. A few alternations of sandy and dolomitic rusty limestone.
	?Middle Speckled Sandstone.	11. Grey clays overlying a boulder bed in places.
		10. Purple and crimson sandstones and clays.
	Lower Speckled Sandstone, Boulder beds.	9. Earthy dark coloured boulder beds, under 200 feet.
		8. Dark grey concretionary shales or clays with *Hyolithes orientalis, Cardiomorpha indica*; 100—150 feet.

(Unconformity ? ?)

Grey group.	Gypsum	7. Gypsum and dolomite and clays with cherty, dark platy, bituminous bands, alternating with pink and white layers of rock gypsum, &c.

I have taken the liberty of introducing in this section the designations as they appear not improbable according to the scheme introduced by me in this work.

The question can, however, not be considered as definitively solved by such a tentative arrangement, and it will be necessary to make further studies on the spot for the full clearance of this matter. Perhaps the unconformity may pass directly below the boulder beds No. 9, and the dark shales may belong already to the lower division. It is true, the occurrence of *Cardiomorpha* is suggestive of a carboniferous age for these beds, but a single form can never definitively settle the age of a bed. Thus my arrangement must be considered as entirely provisional. Whether the middle speckled sandstone be really represented by the beds Nos. 10 and 11; or whether this division is here entirely absent, and the mentioned beds must be counted with the boulder group of the lower speckled sandstone, remains also very doubtful.

The second type which can be distinguished in the development of the boulder group is to be found in the Salt-range proper; and an example of this mode of development has been given already in the section of the Nila-Wan, p. 112. Another section, situated a little further to the west, has been noted by me north of the village of Katta; and I may be allowed to quote it here from my note-book as taken down in the field. The same section has been published already in a somewhat shortened form by Mr. Wynne on pages 209-210 of his Report.

At the lower part of the hillsides along this whole valley behind Katta, not very thickly bedded red or rather purple sandstones are conspicuous; whilst above them a vertically ascending terrace is formed of the compact siliceous limestones composing the middle region of the Productus-limestone. The sandstones can be sub-divided on a closer examination in the following manner:—

At the base there are: (1), about 200 feet of thinly bedded purple or red sandstones, below which at some places more red shales make their appearance. They are everywhere followed by (2), green sandstones and shales, which, however, must be, as in the Nila-Wán, unconformable to the underlying sandstones, as there is no trace of any equivalent of the Magnesian Sandstone nor of the Neobolus-beds present. In the lower region of the green sandstones there occur many pebble-beds of crystalline pebbles, some of the latter reaching the size of real boulders. In the upper region of the sandstones, on the contrary, there were observed many intercalations of a carbonaceous substance, without, however, determinable plant-remains, though I searched much for them. The green sandstones are about 60 to 100 feet in thickness. Above them follow (3) red sandstones, which pass locally into red sand-shales, and are intercalated with many red marl-beds. The thickness of these sandstones is not more than 50 feet. In the upper region of them, beds of lavender clay begin to appear, which by getting more and more numerous cause the sandstones to blend together with a thick division of lavender clay (4), which also reaches again at least 50 feet in thickness. The beds of this division are not all of the same consistence, some being hard true marl-stone, and others soft. Above this lavender clay division follows a shaly green sandstone (5), about 6 feet thick, which passes upwards into a yellow soft sandstone (6) with some undeterminable fossils, remains of fishes and

spirifer. The thickness of this bed is about 10 feet. Higher up, follow (7) black sandy shales with much carbonaceous matter, but without determinable plant-remains, 10—12 feet thick; and above these, reddish nodular sandstones (8), 3 feet, and thick soft yellow and reddish sandstone (9) with many fossils in places, *Fusulina sub-kattaensis*, *Bucania kattaensis W.*, *Productus cora*, Orb., etc. These sandstones are about 20 to 25 feet in thickness. The last beds still belonging to the Speckled Sandstone group are (10) hard grey sandstones, 6—10 feet thick, with many fossils, *Fusulina kattaensis*, Schw., *Spirifer striatus*, Mart., *Marginifera ovalis*, W., etc.

What follows higher belongs already to the middle Productus-limestone and need not be mentioned here.

The interpretation of the present section is a very simple one. It is evident that the whole Speckled Sandstone group rests here unconformably upon the Purple Sandstone, as is the case in the interior parts of the Nila-Wan. Within the speckled sandstone group, the three sub-divisions can easily be distinguished here, as in other sections belonging to the same type. The lower speckled sandstone is represented by the green sandstones No. 2; the red sandstones No. 3 and the lavender clay No. 4 must be counted as belonging to the middle division; whilst beds Nos. 5—10 constitute the upper speckled sandstone or lower Productus-limestone.

The most conspicuous character of the second type of development here under discussion consists in the comparatively insignificant development of the boulder beds which are only rarely of considerable thickness and are mostly a coarse conglomerate, in which larger boulders, sometimes measuring up to the height of a man, are disseminated. The pebbles are nearly all of crystalline rocks, mostly granites and porphyries; and off and on, one is met with showing a glacial striation. If the rock is subject to weathering, the large blocks remain on the top of earthen pillars, such forming true earth-pyramids, as they are to be observed in the glacial deposits on the Ritten near Botzen. The drawings I made of these things were, I regret to say, drowned together with my other property on my return journey from India.

The third type of development is to be met with exclusively in the eastern parts of the Salt-range. I myself have made only very few observations of these beds, as my health was completely broken down when travelling along these parts. On the other hand, there were also not very many fossils reported as occurring in these regions, and thus they also did not strictly fall within the course of my mission.

It is well known that it was Dr. Warth who first brought certain facts to light, which made a representation of the speckled sandstone group in the eastern parts of the Salt-range highly probable. The beds in question had been united by Mr. Wynne with his Olive group, and through Dr. Warth's investigations it was shown that this group had to be divided in two parts—an upper one, corresponding in age to the *Cardita beaumonti* beds of Sind, and a lower one, in which he detected numbers of glacially striated pebbles and concretions with *Conulariæ* and other fossils.

It is this lower part which has been brought, first, by myself and later on also by Dr. Warth on more safe grounds, into connection with the speckled sandstone group. Whether such a correlation be really thoroughly well founded seemed to be

impossible to decide up to very recent times: only quite lately, after I had succeeded in determining definitively the so-called Olive group bivalves, after indescribable troubles, and after all my friends had counselled me to throw away these specimens, which never could be brought into a state fit for determination; there seems to be no avoidance of the conclusion that this lower part of the eastern Olive group is the equivalent of part of the speckled sandstone.

I am, however, not prepared to assert that every conglomerate in the Eastern Salt-range, which may be met with approximately on the horizon of the *Cardita beaumonti* beds or somewhat lower, must be necessarily an equivalent of the speckled sandstone; because it may easily have happened that in the process of overlap that took place during the deposition of the *Cardita beaumonti* beds, the older strata may have been partly destroyed, and their materials have been made use of for building up the newer formation. Such cases occur in which crystalline pebbles as well as even concretions with *Conulariæ* may be found in the true *Cardita beaumonti* beds.

The only section which I myself have taken down in these beds is near Sadowal, which section is also given by Mr. Wynne on page 154 of his Salt-range Report. It is situated at a somewhat unfavourable spot, as its continuation into the nummulitic formation cannot be followed, because the rock-mass, of which the section gives the succession, is cut off towards the mountain side by a fault, which brings the red salt-marl in again apparently over the topmost bed of the section, belonging to the *Cardita beaumonti* beds. There is no use in giving here all the details about the *Cardita beaumonti* beds, so I introduce the section only in an abridged form.

The section runs as follows, taken from my note-book:—

Cardita beaumonti beds.	19—8. Light coloured, white or yellow sandstones with many thin intercalations of coal	80 feet.
	7. Thickly bedded greenish soft sandstone with a few coaly intercalations	4 „
	(Unconformity? ? ?)	
Speckled sandstone.	6. Dark greyish green sandy shales and thinly bedded sandstones	30—40 „
	5. Massive greyish green sandstones, very coarse at places so as to pass into a small-grained conglomerate: large fossil bivalves. *Eurydesma globosum*, Dan., *E. ellipticum*, Dan., *E. cordatum*, Sow., *Maconia gracilis*, Dan., in the lower region	15—20 „
Lower speckled Do.	4. Boulder bed, of a dark green or grey colour, with many large blocks of crystalline rocks	3—30 „
	3. Dark purple shales with a few intercalations of hard green beds	50 „
	(Unconformity? ? ?)	
Red shaly zone.	2. Bright red thinly bedded sandstones and shales, with Salt-crystal Pseudomorphs	100 „
	1. Magnesian sandstone.	

Of these beds, Nos. 4 and 5 are the most important, as in the boulder bed No. 4 numerous glacially striated pebbles occur; whilst at the limit between beds Nos. 4 and 5 besides the large bivalves, numerous concretions have been detected by Dr.

Warth, and were afterwards also collected by Dr. King and Middlemiss, which contain a great many specimens of *Conulariæ* and other fossils.

The section, as just quoted, seems however not to be complete; for at other places still some further equivalents of the speckled sandstone seem to exist, consisting of red sandstones of some thickness. These sandstones have been mentioned already by Mr. Wynne from Batli (page 156 of the Salt-range Report) and are described by Dr. Warth in the Records, Geological Survey, Vol. XX, in the following manner :—

"The greenish sandstones predominate and are more in view in the east, over the area of Wynne's 'Olive series,' whilst the red sandstones are more strongly developed towards the west, over the area of Wynne's speckled sandstone. Although less prominent about Dandot, several drifts were worked through these beds. The purple clay, with its peculiarly crusted surface (Salt-range Report, p. 90) was also well observed at several places.

"The red sandstone at Pid contains petrified wood; brown nodules 3 inches thick with calcite, barite and other crystals inside; red sandy calcareous balls, 1 inch thick, often several of them joined together; also small flat discs, 2 inches in diameter, weathering out, often perfectly circular (once also as a deceptive imitation of a bivalve). All these structural characteristics of the east I found repeated in the speckled sandstone of the west at Varcha, and some of them at Nila-Wan. Instead of difficulty in reconciling the different characters of these rocks, we have thus on the contrary additional evidence which would independently render the identity of the rocks extremely likely."

So it seems that in the eastern parts of the Salt-range not only equivalents of the lower speckled sandstone boulder beds are present, but also the middle speckled sandstone seems to be represented; whilst, on the contrary, every trace of the upper speckled sandstone or lower productus-limestone is decidedly absent.

Thus we have now followed the boulder beds from the west to the east, and have seen that the discrepancies of the different modes of development are not so great that it would not be possible to detect at least a certain similarity between the different types. All of them have one very important character in common, and this is the occurrence of large blocks of crystalline rocks disseminated between a comparatively fine matrix, and the existence of sometimes great numbers of striated pebbles. Both combined go far to suggest the glacial origin of the beds in which they occur. Before, however, we can enter into the discussion of this very important question, it is necessary to take a glance at the organic remains which have been detected in these beds. These can be divided into two sets. The greater number occur in concretions, nodules, or rolled pebbles, which are either intermixed with the boulders as at Nila-Wan, or are found more separately above the boulder beds as in the Eastern Salt-range.

A second set is formed by the large bivalves which occur in the greyish green sandstones at some localities in the east.

I commence my description with the first group.

Fossils contained in the *Conularia*-Nodules.

It was in the year 1885 that Dr. Warth found the first traces of *Conulariæ* in the boulder group of the Eastern Salt-range.

I considered the first specimen that was sent to me as not having been found *in situ*, and I was inclined to attribute it to some silurian species which had been carried down from the Himalayas to the Salt-range. This opinion, which I expressed in a letter to Mr. Medlicott, was, however, not accepted by the learned Director of the Survey, who rather inclined to the opinion that the specimen had been found *in situ* and indicated a palæozoic age for the bed in which it had occurred (Annual Report for 1885). How rightly he had judged the case appeared soon from further finds made by Dr. Warth in these beds, which revealed a whole palæozoic fauna, which up to this had been perfectly unknown in the Salt-range, and which was found to be allied to a certain extent to the upper carboniferous fauna contained in the Australian coal measures.

In the Records for 1886 I gave a short review of the species that were contained in the first more extensive set of these fossils sent to me by Dr. Warth. There were then about ten species. Later on some more materials came into my hands, and I am now in a position to augment the list rather considerably.

The species are the following:—

1. Pleurotomaria nuda, Dana, Pl. IV, fig. 4a, b. c.

1849. *Pleurotomaria nuda*, Dana: United States Exploring Expedition, Vol. X, Geology, p. 706, pl. IX, fig. 17.

There is a single specimen of this species contained among my materials which consists of an internal cast, as has apparently been also Mr. Dana's original.

The cast is of moderate size, about 13mm. high and 15mm. broad with rounded whorls, of which I count five. The specimen is, with the exception of the absence of every trace of a shell, entire, and the aperture is clearly recognisable: it bears a very long and narrow slit. The slitband is slightly raised and thus interrupts a little the general roundness of the whorls.

The general outline is, as appears already from the measurements given, tolerably elevated conical, the apical angle being about 85°, while the whorls project well one above the other. The basal side bears a deep, but not very wide, umbilicus.

According to Dana's figure the present specimen agrees very well with the Australian form, and I think there cannot be much doubt that both belong to the same species. It is to be noted, however, that the figure does not agree well with the text which gives to the form an apical angle of 115°, whilst the figure shows not more than 80°.

Dana collected his specimen at Harpur's hill, N. S. W.

The nodule in which the present specimen was contained was collected by Dr. Warth at the upper limit of the boulder beds at Dillur.

2. Bucania warthi, Waagen, n. sp., Pl. IV, fig. 1a—f, fig. 2a—c, fig. 3.

1886. *Bucania* cf. *kattaensis*, Waagen : Records, Geol. Surv., Ind., Vol. XIX, pt. I, page 27 (*non* Buc. kattaensis, W. Saltr. Foss., Vol. I, p. 151, pl. XIV, fig. 6, 1880).

When I wrote the little note on the fossils of the Olive group for the Records of 1886, there was nothing but an internal cast of this species known to me, which has now been figured Pl. IV, fig. 2. I was not able to determine this specimen definitively, and so I could not do anything but compare it to *Bucania kattaensis* to which in its general appearance it showed a great similarity. That I was not very far from the truth has been demonstrated by the find of several specimens preserving their shell, and which show that the species was in reality very nearly related to *Bucania kattaensis*.

Yet I cannot advocate the identification of this form directly with the mentioned species formerly described by me.

The general outline of the shell is nearly globular, the height and breadth being about equal. The whorls are very strongly inflated, rapidly increasing, with a broad slightly obtusely pentagonal section. They do not envelope each other entirely, but leave a very small and deep umbilicus open. In the middle of the peripheral part of the shell, there is a not very broad slightly raised slitband, which appears however more prominent in the internal casts than on the specimens which have preserved their shell.

The surface of the shell is not very excellently preserved in the specimens at my disposal; still it can be seen that it was covered entirely by a fine spiral striation which is most distinctly preserved in the vicinity of the umbilicus, but which can at the same time be distinctly observed to extend also over the other parts, so that even the slitband is not free from it. The slitband itself, if well preserved, is seen to be hemmed in on both sides by slightly more strongly raised spiral ridges.

This whole system of spiral striation is crossed by very numerous striæ of growth, which, however, can also be observed only at some places, where the surface has been less strongly deteriorated. They proceed from the umbilicus over the sides of the whorls, forming a low arch directed towards the front, and on reaching the slitband are suddenly deflected backwards, crossing the latter in a distinct reversed arch.

By these two systems of sculpture the whole surface of the shell appears reticulated or cancellated.

The shell is rather thin and fragile, only slightly thickened in the umbilical region.

The chief distinguishing characters of the species can be most easily recognised if the specimens are looked at from the mouth. The latter appears then distinctly pentagonal, though the corners are all well rounded off. From the raised slitband, the peripheral side slopes in a flatly rounded curve towards the lateral parts; then the outline rather suddenly bends down to form the lateral parts, which also show a rather flat curve, and again bend rather suddenly in to form the umbilicus. Thus

an indistinct pentagon is formed, a shape of the mouth, which is very characteristic of the present species.

The incision at the outer lip is not very long and rather narrow.

On the whole it cannot be denied that the present species bears a very great resemblance to *Bucania kattaensis*, though it can readily be distinguished by the pentagonal outline of its mouth and by the somewhat narrower slitband. There is however but little doubt that the two stand in a developmental connection.

In the description of *Bucania kattaensis* I have brought this species into connection with *Bucania decussata*, Flem., and have expressed the opinion that the latter had to be probably considered as the ancestor of the former species. It was not possible then to arrive at any more concise opinion. Now, however, after the publication of the Gasteropoda of the great work of M. de Koninck on the carboniferous fossils of Belgium, the case is different. On pl. 42 *bis*, of this excellent publication, exact figures of *Bucania decussata*, Flem., as well as of *Bucania striata*, Flem., have been given, and from these it appears that the Indian species show a closer relation to the latter than to the former species; so that *Bucania striata* will have to be considered as the ancestor of the Indian forms rather than *Bucania decussata*.

We have thus a well distinguishable developmental series from *Bucania striata* to *Bucania kattaensis* as the geologically youngest form, in which all the members are characterised by a slitband that is very closely spirally striated; and by an external side that is strongly raised, nearly roof-shaped in the geologically oldest species and becoming more and more depressed and rounded in the geologically younger forms.

Bucania warthi thus fits beautifully in as a connecting link between *Bucania striata* and *Bucania kattaensis*.

Before concluding this note on a shell belonging to the family of the *Bellerophontidæ*, I may be allowed to make a few remarks on some criticisms that have been made with regard to several genera I have accepted or proposed for different forms of the family. There is first my dear and most regretted old friend M. de Koninck's great work on the carboniferous fossils of Belgium, in which some changes with regard to my genera are proposed. Before all, the name *Patellostium* proposed by me must be suppressed, as it is identical with *Salpingostoma* of F. Roemer, which had been overlooked by me. Then M. de Koninck wishes to unite *Mogulia* with *Warthia*, which, however, I should not like to advocate, as I have proposed the latter name for entirely smooth shells, whilst *Mogulia* bears a distinct sculpture. The shell of *Mogulia* is also much heavier and provided with a strong callosity on the inner lip, characters which are absent in *Warthia*.

Another criticism of my genera is contained in Lindstroem's "Silurian Gasteropoda of Gotland." On page 71 of this work, Mr. Lindstroem wishes to erase the genera *Warthia*, *Mogulia*, *Stachella* and *Euphemus* altogether from the family *Bellerophontidæ*, considering them juvenile forms of *Goniatites*. I would gladly admit such a position for my genera if Mr. Lindstroem had been able to demonstrate in a

single example of the species described by me the existence of septa and sipho. As I myself however, notwithstanding having taken the greatest trouble, have failed to detect any such, I must decline to accept Mr. Lindstroem's views, and can only express my regret that thus, without any proofs, my determinations have been drawn into doubt.

Bucania warthi here described was found by Dr. Warth at Dillur and Chél, and one of the nodules from the latter locality contained several specimens.

3. Conularia lævigata, Morris: Pl. IV, fig. 5a—g; Pl. III, fig. 1a. b, fig. 2a. b.

1845. *Conularia lævigata*, Morris: in Strzelecki, Phys. descr. of New South Wales, p. 290, pl. XVIII, fig. 9.
1877. *Conularia lævigata*, (Morr.) Koninck: Foss. Paléoz. de la Nouv. Galles du Sud., p. 313, pl. XXIII, fig. 1.
1886. *Conularia lævigata*, (Morr.) Waagen: Rec., Geol. Surv. of India, Vol. XIX, p. 25, pl. I, fig. 1.

In 1886 I characterised the species in the following manner:—

This species attains rather considerable dimensions, but by far the greater number of specimens found in the concretions are small young specimens; only exceptionally are individuals met with so large as the one figured by me, or even larger. The species is somewhat variable, as I have tried to illustrate by different figures.

The most striking characters, which always hold good, are: first, the rectangular, not quadratic, section of the cone; second, the always smooth condition of the ribs, and lastly the very regular distribution of these, so that always ten to twelve can be counted within the distance of 10 mm.

The variability of the shell chiefly consists in the arrangement of the ribs, which are generally arranged in such a manner that in the middle of the faces of the pyramid, where the ribs meet under an obtuse angle, they alternate with each other; sometimes, however, in one and the same specimen, they do not alternate but unite directly with each other, and then form simply bent lines.

The species seems to be most nearly related to *Conularia ornata*, d'Arch. and Vern., from the Devonian and to *Conularia quadrisulcata*, Sow., from the Carboniferous period. From both it is different by its rectangular section, from the former also by its smaller apical angle, which is only 15°, whilst it is 20° in *Conularia ornata*, and from the latter by its coarser transverse striation.

There cannot, I think, be much doubt about the determination of this form. The transverse section, the number of the ribs, the apical angle, all are identical with *Conularia lævigata*, and thus we can safely unite the Salt-range form with the Australian species.

I have not much to add to the description formerly given; except that it seems necessary to make a few remarks with regard to the state of preservation of the specimens.

The present species is the most frequent one occurring in the *Conularia* nodules; and among the hundreds of specimens that have been collected there were a few which were not contained in nodules, but which were free, only enclosed in the coarse conglomeratic sandstone, of which the boulder bed is made up for its greater part. Such a specimen I have figured Pl. III, fig. 1, and it can well be seen that it looks as if rolled like another pebble. The sculpture is preserved only on one of the lateral faces, and on the side with which it is yet partly adherent to the rock; on the other sides the sculpture is nearly entirely worn off. The specimen is there rounded as well as on the upper and lower extremities. Is this deterioration of the specimen caused by rolling, and must the specimen be thus considered as in a secondary position? This question, it seems to me, can barely be solved definitively from the specimen itself, though apparently the excellent preservation of certain parts of the surface can hardly be explained if one accepts the opinion that the specimen has been rolled and transported from distant parts. From what I have seen in my life of transported fossils in a secondary position, the specimens were invariably deteriorated on *all* their prominent parts; whilst only those parts which were depressed below the general level were well preserved. Just the corner of the *Conularia*, which is represented in fig. 1 b, is the most intact part of the whole fossil, and yet it is one of the most prominent. May it not be that, notwithstanding the general appearance, the specimen is not rolled, but that its aspect is caused by some other process; be it, by an incomplete formation of the nodule or by a partial exposure to weathering, be it on the surface of the rock, or in a crevice within the rock?

As I have remarked above, I scarcely think this question can be solved definitively from the consideration of this specimen alone. And yet the question is a very important one, for if this specimen be a rolled one and in a secondary position, then a similar derivative origin for the other specimens contained in nodules seems highly probable. That the greater part of the specimens occur really in nodules, which on their part might be in a secondary position, a thing that I cannot absolutely deny *a priori*, and not in rolled pebbles, appears evident from fig. 2 on Pl. III, which represents two of those nodules contained in a small piece of rock, one of them enclosing a *Conularia*, the other without any fossil.

The question, however, whether a secondary position must be accepted for all these things, cannot be discussed now, before all the fossils have been described in detail. Thus I shall have occasion to recur to this point later on.

Conularia lævigata is apparently a rather common species in the Salt-range, having been found by Dr. Warth at numerous localities from the Nila-Wan to Mount Chél.

In Australia it has been found according to Strzelecki's indications at Illawara and Raymond Terrace. Dana and M'Coy quote it from Harpur's Hill and Black-Creek. The Rev. W. B. Clarke has collected it in the quarries at Murree and also at Raymond Terrace, where it has been found together with plant-remains that have been determined by M. Crepin as *Schizopteris*.

4. Conularia tenuistriata, M'Coy, Pl. V, fig. 2 a, b, c, fig. 3 a, b, c, d.

1847. *Conularia tenuistriata*, M'Coy: Annals and Mag. Nat. Hist., Vol. X X, page 307, pl. XVII, fig. 7, 8.
1877. *Canularia tenuistriata*, (M'Coy) Koninck: Foss. paléoz., de la Nouvelle Galles du Sud, Vol. II, p. 310, pl. XXIII, fig. 2.
1886. *Conularia tenuistriata*, (M'Coy) Waagen: Records, Geol. Survey of India, Vol. XIX, pt. I, p. 26, pl. I, fig. 3.

In my former paper the species is described as follows:—

The shell must have been extremely long as the apical angle is not more than 10°. The transverse section of the pyramid is somewhat lozenge-shaped, possessing, however, two broader and two considerably narrower faces. The latter are rather deeply impressed in the middle. The four faces are covered with a rather fine transverse plication. The single folds are broken in the middle of each face and there mostly alternate. The folds are smooth on the top and very fine. There are 19 to 20 within the space of 10 mm. In the grooves between the folds a very fine oblique striation is observable. These characters will suffice to recognise the species.

To this description I have yet some points to add.

The sides of the shell are not always so strongly impressed in the middle as was the case in the first specimen found of the species. The four corners of the shell bear a deep furrow in which the ribs from both sides alternate, without any swellings appearing between them. The fine striation between the ribs is not present everywhere, but only at certain places which are quite irregularly distributed, probably according to the different progress of weathering at different places.

The transverse section is always rhomboidal, one of the diagonals being considerably longer than the other. In the Indian specimens the difference of breadth between the two sides of the shell is not quite so strong as in the Australian ones, the narrower side being slightly more than half the breadth of the broader one. Also the number of ribs is not quite in accordance with M'Coy's indications, who counts 27 to 29 within the space of half an inch; but in this respect it must be taken into consideration that the Indian specimens are considerably smaller than the one that served for Mr. M'Coy's description, and that only the upper broader end of this specimen is preserved. It is a well-known fact that in nearly all species of *Conularia*, which are provided with transverse ribs, these latter are generally considerably more closely set towards the upper extremity than lower down towards the apex of the cone. The difference between the Indian and Australian specimens is, however, not so very great; for in M'Coy's drawing I count in different parts of the figures between 17 and 25 ribs within the space of 10 mm.; whilst within the same space on the Indian specimens it is between 17 and 20.

Both authors, who have treated up to the present of the species, M'Coy as well as M. de Koninck, have pointed to the great similarity that exists between it and *Conularia gerolsteinensis* of Devonian strata. There is a like similarity to *Con. brogniarti* of the same formation. From the first it differs by the more acute apical angle and its smooth ribs, and from the second by the greater number and fineness of the transverse ribs.

From *Conularia lævigata*, Morr., which occurs in great numbers together with the species here under consideration in the Indian deposits, it can be distinguished on a first glance by its much finer transverse striation.

Conularia tenuistriata is rather rare in the Salt-range, and there is no specimen, except the two figured on Pl. V, which I can attribute with certainty to the species. Others, which also might belong to it, are too indifferently preserved to judge definitively as to their proper determination.

The species was found by Dr. Warth at Dillur and at Chél hill.

In Australia it has been quoted up to the present exclusively from the micaceous sandstone of Murree.

5. CONULARIA WARTHI, Waagen, n. sp., Pl. IV, fig. 6 a, b, c, d; Pl. V, fig. 1 a, b.

1886. *Conularia* cf. *irregularis*, (Kon.) Waagen: Rec. Geol. Surv. of India, Vol. XIX, p. 26, Pl. I, fig. 2 (non *Conularia irregularis*, Koninck).

This shell is elongately conical, of moderate size. Its apical angle is 12°. The entire length of the best preserved specimen was 86 mm., of which a length of 69 mm. is in reality preserved; whilst the remaining 17 mm. at the apex have been broken away. The cone has four sides, which are of about equal breadth, and moderately impressed in the middle. The transverse section is rhomboidal, one of the diagonals being considerably longer than the other. At each of the four corners of the cone, there extends all along a strongly marked furrow.

The four sides are covered by tolerably fine transverse ribs, of which there are 11 to 16 within the space of 10 mm. From both sides they ascend towards the middle, where they are interrupted, whereby a kind of flat, indistinct furrow is formed. The ribs from both sides do not generally correspond in the middle, but alternate more or less distinctly. At the corners they descend into the furrows in bending a little upwards. At both sides of the furrows there are little tubercles situated between the single ribs (fig. 6 d.).

The transverse ribs themselves are ornamented on their tops with a fine but distinct granulation, which is in connection with a fine somewhat irregular plication that extends transversely over the spaces or valleys between the single ribs.

The present species seems to be most nearly related to *Conul. quadrisulcata*, Mill., of which species M. de Koninck has given an excellent characteristic in his "Fossiles paléozoiques de la Nouvelle-Galles du Sud." Some striking differences are however recognisable on a first glance. Before all, the apical angle of *Conul. quadrisulcata* is much more considerable (20°) than in the Indian species in which it is only 12°. Then the English carboniferous species has flattened or vaulted sides; whilst these are depressed in the middle in the Indian form. That this latter peculiarity is a character of the species and not caused by chance and mode of preservation, is shown by the regular occurrence of this character in all the many specimens of this species that have come under my notice.

A further difference consists in the transverse ribs, which are much finer (24

within the space of 10mm.) in *Conul. quadrisulcata* than in the Indian species (11—16 within the same space). The minute sculpture on the contrary, the granulation of the transverse ribs and the somewhat irregular plication on the spaces between, is identical in both species.

At the time of writing my note in the Records, I had only a single specimen of the species at my disposal, and this seemed to me to exhibit a certain relation to *Conularia irregularis*, Koninck. It was chiefly the large apical angle the specimen seemed to possess which caused me to compare it to *Conul. irregularis*. Now, with so many well-preserved specimens to hand, it cannot be doubted any more that the appearance of a large apical angle in the single fragment formerly at disposal was caused solely by a singular deformation the specimen had undergone, as all the other specimens show a small apical angle and a regularly rhomboidal section, though in all other points they are identical with the first fragment.

Nevertheless, a certain similarity of the species here under description to *Conularia irregularis*, Kon., cannot be denied; though, on the other hand, the differences are also very striking. Before all, the difference in the breadth of the adjacent spaces of the cone, on which character great stress is laid by M. de Koninck, does not exist in the Indian species. Strange to say, this character also does not appear in M. de Koninck's drawings in the Annales du Musée Royal de Belgique, Vol. VI, Pl. 54; though it is very well expressed in the figure contained in the "Déscription des Animaux fossiles," Pl. XLV, fig. 2*a*, *b*. A second difference consists in the smaller apical angle and the coarse ribs of *Conularia warthi*. The minute sculpture of this latter species is also more in accordance with *Conularia quadrisulcata* than with *Conularia irregularis*.

Numerous specimens of the species were collected by Dr. Warth in Chél hill and at Dillur.

6. Sanguinolites *cf.* mitchellii, Koninck, Pl. V, fig. 4*a*, *b*, *c*.

1876. *Sanguinolites mitchellii*, Koninck: Foss. Paléoz. de la Nouvelle-Galles du Sud, Vol. II, p. 261, Pl. XVI, fig. 3.

It does not appear possible to determine the specimen figured on Pl. V definitively, it being too fragmentary for the purpose. So much, however, is beyond all doubt, that the specimen belongs to the genus *Sanguinolites*, in which the thin shell and the strongly bent-in beak are characteristic.

The fragment is of a rather small specimen, much smaller than M. de Koninck's original. It represents only part of the left valve, just the apical region, with parts of the hinge margin. It is very strongly inflated and covered with numerous concentric plications, on which the shell is partly yet preserved. This latter is so very thin that the sculpture on the internal cast and on the shell is absolutely identical.

The beak is but little prominent and strongly incurved, and seems to have been placed rather anteriorly on the shell. How far the shell extended posteriorly can-

not be seen; but on the whole it is not improbable that the general outline was much like that of M. de Koninck's species, and as represented in the drawing on Pl. V.

Of the hinge-apparatus nothing can be made out.

The characters that can be observed on the specimen are not sufficient to determine the species definitively; but from what can be observed it appears rather probable that the general form of the shell was much like that of *Sanguinolites mitchellii*.

The one specimen of this species was worked out of a nodule containing *Conularia lævigata* collected by Dr. Warth at Dillur.

M. de Koninck quotes the species from Aellalong and Wollongong.

7. Sanguinolites tenisoni, Koninck, Pl. V, fig. 6*a*, *b*, *c*.

1879. *Sanguinolites tenisoni*, Koninck: Fossiles Paléoz. de la Nouvelle-Galles du Sud, Vol. II, p. 265, Pl. XVII, fig. 5.

The specimen serving for description is considerably smaller than M. de Koninck's original, and there are also other slight discrepancies which will be pointed out presently; but, on the whole, the Indian shell shows so much similarity to the one figured in M. de Koninck's work that I think it may be safely quoted under the same name.

The shell is but very little vaulted in every direction, and the beak but very little prominent, situated in the anterior third of the entire length of the shell. The cardinal margin is straight, the ventral one a little arched. The anterior margin is rather narrowly rounded, the posterior one is considerably broader, but also perfectly rounded. The shell has been deformed a little, evidently by disease, wherewith a shallow furrow has been formed which extends not far from the hinge-line from the apex to the posterior margin causing the sculpture to become somewhat irregular.

The sculpture consists of high concentric lamellæ, of which I count about nine, between which a very fine concentric striation is visible, similar to that appearing in well-preserved specimens of *Sang. plicatus*, Portl.

The substance of the shell is extremely thin, and the sculpture on the cast identical with that on the shell.

The dimensions of the shell are as follows:—

Entire length of the shell, probably	23 mm.
„ breadth of the shell	12 „
„ thickness of one valve	5 „
Distance of the apex from the anterior margin	7 „

In all its characters the Indian specimen agrees well with *Sang. tenisoni* except in the position of the apex and the number of concentric folds. The position of the apex is somewhat less terminal, and the folds more numerous by two.

In these latter two characters the Indian specimen approaches more *Sang. plicatus*, Portl., with which species the Australian one has been rightly compared by

de Koninck; but both these characters are far more strongly developed in Portlock's species.

So I think the Indian specimen may be safely united with *Sang. tenisoni*, though too great stress cannot be laid on the identification, the specimens being of too unequal sizes.

De Koninck's original was collected by the Rev. W. B. Clarke at Burragood in an olive-grey argillaceous limestone.

The only specimen found up to the present in India was worked out from a *Conularia* nodule collected by Dr. Warth at Chél hill.

8. Nucula sp. indet., Pl. V, fig. 5*a*, *b*, *c*.

1886. *Nucula sp. indet.*, Waagen: Rec. Geol. Surv. Ind., Vol. XIX, page 27, Pl. I, fig. 6.

The figured specimen on Pl. V has already served for description in my note in the Records. It is too small to make out even the generic characters, and the other two specimens that were contained in the same nodule are too fragmentary.

It is probable that the thing is a Nucula, and in one of the fragments it appears as if a slight impression of the dentition were observable, but one cannot be sure of the matter.

The valves are very strongly inflated and the beaks shifted only very little towards the front, nearly median in their situation, but little prominent and strongly incurved. The whole surface is covered by a fine concentric striation.

Three species of *Nucula* have been figured by Dana from Australian beds, but with none of these can our Indian form be compared, as here the beaks have a more decidedly median position than in any of Dana's species.

The specimens were collected by Dr. Warth in *Conularia* nodules at Dillur.

9. Pseudomonotis subradialis, Waagen, n. sp. Pl. V, fig. 7*a*, *b*, *c*.

The only specimen of this species that has come under my notice is that figured on Pl. V, a left valve, in which the shell is not entirely preserved.

The shell is of very small size and nearly circular in its outline, only very little higher than it is long. It is tolerably vaulted, the hinge-line straight, not quite as long as the entire length of the shell. The beak is but very little prominent, well pointed and not bent over. There are wings at both sides of it, the anterior one smaller, the posterior larger. The anterior wing is obtusely angular, not cut out and passing gradually into the anterior margin of the shell; the larger posterior wing is also obtusely angular, a little cut out at its base and thus more distinctly marked off from the body of the shell than the other one. The outline projects posteriorly considerably over the termination of the wing, and thus becomes somewhat oblique.

The sculpture of the shell consists of strong radial ribs, a certain number of which reach up to the apex, whilst others, shorter ones, are intercalated between them towards the margin of the shell. At the margin, 12 ribs can be count-

ed altogether. The ribs appear in general smooth, but if looked at obliquely one can observe that they are a little smaller from distance to distance, a circumstance which points to the former existence of a concentric sculpture which has been destroyed by bad preservation. The wings are without any sculpture.

The dimensions of this little shell are as follow :—

Entire length of the shell	8 mm.
„ height „ „	9 „
Length of the hinge-line	5 „
Thickness of the left valve	2·5 „

The species which seems to be most nearly related to the present one is *Pseudomonotis radialis*, Phill.; the radial plication, however, and apparently also the concentric sculpture, is much coarser in the Indian shell than in the species of the European magnesian limestone.

This little shell was taken out of a *Conularia* nodule collected by Dr. Warth at Dillur.

10. Aviculopecten *cf.* limæformis, Morris, Pl. V, fig. 8.

1845. *Pecten limæformis*, Morris : in Strzelecki, Phys. Descr. of New South Wales, p. 277, Pl. XIII, fig. 1.
1877. *Aviculopecten limæformis*, (Morris) Koninck : Foss. Paléoz. de la Nouvelle-Galles du Sud, Vol. II, p. 291, Pl. XXII, fig. 4.
1886. *Aviculopecten* cf. *limæformis*, (Morr.) Waagen : Rec. Geol. Surv. of India, Vol. XIX, p. 27, Pl. I, fig. 8.

No further specimen of this species has turned up among the material sent recently to me, and thus I am unable to give any more particulars about it.

Nothing can be observed in the specimen but the sculpture of part of the shell, which is, however, very considerably smaller than M. Morris' original. The sculpture nevertheless is very similar. The ribs, which are all simple and not divided, are of unequal strength, in which characters they absolutely agree with *Aviculopect. limæformis.*

The fragment was collected by Dr. Warth at Dillur.

In Australia, the species has been quoted by Morris from Tasmania; by M. de Koninck from Murree and Wollongong; and by Daintree from Queensland.

11. Spirifer vespertilio, Sow., Pl. V, fig. 10*a*, *b*, *c*.

1844. *Spirifera vespertilio*, Sow.; Darwin, Geolog. Observ. on Volc. Islands, p. 160.
1845. *Spirifer vespertilio*, (Sow.) Morris : in Strzelecki, Phys. Descr. of New South Wales, p. 282, Pl. 17, fig. 3 (*non.* figs. 1 and 2).
1847. *Spirifer vespertilio*, (Sow.) M'Coy : Ann. Mag. Nat. Hist., Vol. XX, p. 232.
1849. *Spirifer phalæna*, Dana : Unit. States Expl. Exped., Vol. X, Geology, p. 685, Pl. II, fig. 4.
1872. *Spirifer vespertilio*, (Sow.) Etheridge, Sen.; Quart. Journ. Geol. Soc., Vol. XXVIII, p. 329, pl. 16, fig. 2.
1876. *Spirifer vespertilio*, (Sow.) Koninck : Foss. Paléoz. de la Nouvella-Galles du Sud, Vol. II, p. 242, Pl. XIII, fig. 4; Pl. XIV, fig. 3.
1887. *Spirifer vespertilio*, (Sow.) Waagen : Jahrbuch d. k. k. Geolog. Reichsanst, Vol. XXXVII, p. 178.
1888. *Spirifer vespertilio*, (Sow.) Waagen : Rec. Geol. Surv. Ind., Vol. XXI, p. 118.

There has been some confusion about this species, which has been completely cleared up by M. de. Koninck. Specimens had been under this name by Morris and

Dana, which evidently belong to a different species, which is very nearly related, if not identical, with *Spir. convolutus*.

The materials of this species collected by Dr. Warth are very limited, consisting only of a tolerably complete dorsal valve and of some fragments of a second specimen of the same valve. Both specimens belong to the rounded variety figured on Pl. XIV of de Koninck's work.

The general outline of the dorsal valve is elongately transversely ovate, with rounded lateral margins. The hinge-line is somewhat shorter than the greatest breadth of the shell, which latter is situated a little downward from the former. It joins the lateral margins of the shell under obtuse angles. The apex of the shell is but little prominent and tolerably strongly bent over.

The valve is tolerably strongly inflated, and bears a high mesial ridge that is divided in the middle by a deep furrow. At both sides of the mesial ridge there extend eight to nine folds in a radial direction from the apex to the margins of the shell.

The area of the valve is narrow and not clearly visible.

The specimen represents an external cast without a trace of the shell.

There cannot be any doubt that the specimen belongs to Sowerby's species. This specimen holds just the middle between the two specimens figured by M. de Koninck on Plates XIII and XIV of his work. In its size it is also about equal to the Australian specimens.

The measurements are the following:—

Entire length of the shell	30 mm.
„ breadth „ „ „	52 „
Length of the hinge-line	45 „
Thickness at the mesial ridge	19 „

The Indian specimens were not found in association with the *Conularia*-nodules. They occurred in a block of greyish brown sandstone much resembling certain varieties of the Olive sandstone of the Olive group, which Dr. Warth found in the foundations of a tumble-down hut near Dillur. From this it is doubtful whether the species ought to be counted with the present set of fossils or with those from the Olive sandstones: as, however, both are but slightly different in age, this is not of very material importance.

The present is one of the most common species of the Australian carboniferous rocks. It occurs at numerous localities in New South Wales, Stony Creek, Raymond Terrace, Anvil Creek, &c., in Queensland and Tasmania.

12. Martiniopsis darwini, Morris (*Jun.*), Pl. V, fig. 9a, b, c.

1845. *Spirifer darwini*, Morris: Strzelecki's Phys. Descriptn. of New South Wales, p. 279.
1876. *Spirifer darwini*, (Morris) Koninck: Foss. Paléoz. de la Nonvelle-Galles du Sud, Vol. II, p. 230, Pl. X, fig. 11; pl. XI, fig. 10, Pl. XVI, fig. 1.
1879. *Spirifer darwini*, (Morr.) Etheridge, Jun.: Proc. Roy. Phys. Soc. of Edinburgh, Vol. V, p. 281, Pl. VII, fig. 1—10; pl. VIII, fig. 11.
1883. *Martiniopsis darwini*, (Morr. sp.) Waagen: this work, Vol. I, p. 525.

The specimen worked out of one of the *Conularia*-nodules is a very small one

consisting only of part of the dorsal valve which yet retains its shell. On a first glance it has very much resemblance to a *Spiriferina*, and I for a long time tried to determine it as such, when I compared it chiefly to *Sp. multiplicata*, Sow., but the depression in the middle of the median fold was a thing that I never had observed to occur in the mentioned species. So after much pains-taking I found that the only species which in all the chief characters appeared similar to the Indian specimen was *Martiniopsis darwini*, Morr., from the Australian Carboniferous.

The general outline of this dorsal valve is transversely oval, the specimen being about one-half broader than it is long. The outline is everywhere well rounded and the hinge-line considerably shorter than the greatest transverse diameter of the shell. The apex is not very strongly pointed, barely bent over, and but little prominent.

The shell is not much vaulted, but more so in the longitudinal than in the transverse direction. It bears in the middle a tolerably prominent median fold, which is in the middle depressed by a shallow furrow. At each of the median folds there are four broad ribs, which are perfectly rounded on their tops and extend in a radial direction from the apex towards the margins of the shell.

The shell surface is rather strongly corroded by weathering, but some concentric lines of growth can be observed which are a little lamellar and imbricating and cross the lateral folds very distinctly. Under the lens one can observe at places a trace of the granulation of the shell, characteristic of the genus, but so far deteriorated by weathering that the grooves in which the granules had been placed have become elongate instead of being round.

The dimensions of the specimen are as follow :—

Entire length of the shell	13 mm.
„ breadth „ „	18 „
Length of the hinge-line	14 „
Thickness of the valve	5 „

There cannot be much doubt about the determination of this specimen as *Martiniopsis darwini*, notwithstanding its small size. All its characters are so much in accordance with Morris' species that nothing remains but to consider it as a young specimen. The nodule which yielded the present specimen was collected by Dr. Warth at Dillur.

In Australia *Martiniopsis darwini* is one of the most characteristic and most widely spread species of the marine division of the carboniferous series. It has been found at nearly all localities of New South Wales and Queensland.

13. Chonetes cracowensis, Etheridge, Sen.

1872. *Chonetes cracowensis*, Etheridge : Quart. Journ. Geol. Soc., Lond., Vol. XXVIII, p. 336, Pl. XVIII, fig. 2.

A fragmentary specimen of this species was detected by me, after the plates

had been completed, in breaking one of the nodules sent to me by Dr. Warth; and thus I have not been able to give a figure of it yet.

It consists merely of the apical region of the ventral or larger valve. The apex is very little prominent and not bent over, the hinge-line straight, the valve itself a little vaulted. The surface is covered by a very fine radial striation, in which the tops of the little striæ are covered by comparatively rather stout spines. On the wings, which are indistinctly marked off from the remainder of the shell, the striation is less distinct.

In all these characters the specimen agrees absolutely with the figures and description given by Mr. Etheridge, and thus the identity of the Indian specimen with the Australian species appears to be beyond all doubt.

The species has been compared by Etheridge to *Chonetes hardrensis*, Phill., and thus it probably belongs to that group of carboniferous species of which *Chon. lagnessiana*, Kon., is the type: it is, however, distinct from this latter form in the greater flatness of its valves. In this respect it can perhaps better be compared to *Chonetes squama*, W., described in Volume I of the present work. In this case, however, the nearly entire absence of spines on the radial striæ forms a striking difference from *Chon. cracowensis*.

The Indian specimen occurred in one of the nodules together with a specimen of *Chon. lævigata*, Morr., collected by Dr. Warth at Dillur.

Mr. Etheridge's originals came from the Cracow Creek in the Bowen river coal-field in Queensland.

14. Discina sp. indet., Pl. V, fig. 11.

1886. *Discina sp. indet.*, Waagen: Rec. Geol. Surv. Ind., Vol. XIX, p. 27, Pl. I, fig. 9.

In my paper in the Records I have characterised the species in the following manner:—

"A very large *Discina*, of which, however, there is but one imperfect specimen."

Fragments of both valves are preserved, and the slit-like aperture of the lower valve can be well distinguished. Both valves are rather flat. The upper valve seems to be granulated on its outer surface. Otherwise both valves are ornamented only with a fine concentric striation.

As no other characters can be made out, it seems inadvisable to express any opinion as to the specific affinity of this shell; nevertheless it must be remarked that we have to deal here with a true *Discina*, and not with one of the genera occurring in the Neobolus beds of the Salt-range.

As no new materials of this species have been received since the above description was written, I cannot add any new observations to those already stated.

The single specimen was collected by Dr. Warth at Dillur.

15. Discinisca warthi, Waagen, Pl. V, fig. 12*a*, *b*, fig. 13*a*, *b*, fig. 14, 15.

1886. *Atomodesma (?) warthi*, Waagen: Rec. Geol. Sur. Ind., Vol. XIX, p. 27, Pl. I, fig. 7.

At the time of my first description of this species, there were only some badly preserved specimens of the larger valve known to me; and I stated at the time that I was rather at a loss as to what genus the species should be attributed.

Since that time, a great many specimens have been sent to me, and I have now sufficient material to try to work out the hinge-line of these things, which I supposed to be bivalves. For a long time I was unsuccessful with any of the specimens as they broke; nevertheless I became better instructed. At last I found a specimen, which, in chiselling at it, all of a sudden split in two and unveiled the perforated valve of a *Discina*-like fossil. Now I knew how to treat the things, and soon other specimens were brought to exhibit also their undervalves; and thus it was certain that I had to deal with a *Discina*-like thing, belonging to the genus *Discinisca*, Dall.

The upper or imperforate valve is very irregular in its general outline. It is always rather strongly inflated and has got mostly a quite marginal apex. Sometimes, however, the apex is shifted somewhat more upwards, and the shell exhibits the appearance represented in fig. 14. In all cases, this valve appears more or less similar to one valve of a Pelecypod shell.

The outline is always more or less elongately oval, never quite circular. Its surface is rather smooth, when well preserved quite shining, but mostly much deteriorated by weathering.

In some specimens the interior surface of the shell bears a fine radial striation. A certain number of concentric striæ of growth can mostly be observed, but they are generally not very strongly expressed.

Nothing can be observed of the interior characters of this valve owing to the generally rather bad preservation of the specimens.

The lower or perforated valve is either quite circular in its outline or also somewhat elongately oval. I know only the interior side of this valve, as the outer side always adheres so firmly to the rock that it cannot be removed. Somewhat above the centre of the shell there is an elongate foramen, broadening and flattening towards the upper margin. The shell substance of this valve always splinters away for the greater part in splitting the shells for exposing the lower valves, and thus I am not able to give more accurate descriptions of these things. Mostly concentric striæ of growth are exposed; but of muscular impressions, etc., nothing can be seen.

It is remarkable in these things that nearly always both valves adhere to each other; whilst of all the other fossils, even the brachiopoda, only single valves have been found. It seems that only these *Discinisc*æ have lived on the spot where the nodules were formed; whilst all the other things were transported from a distance before they were enclosed in the nodules.

The only species with which the present one can be compared and with which a rather close relation exists is *Discina kashmiriensis*, Dav., from the carboniferous deposits of the Kashmir valley. I should have united the two forms, did not Davidson's species show larger dimensions and a more inflated upper valve. The affinity is, however, at all events a very close one.

The species seems to be very common in the *Conularia* nodules, and has been collected by Dr. Warth at all the localities where the nodules occur, as at Dillur, at Chél hill, etc.

16. SERPULITES UNDULATUS, Waagen, n. sp., Pl. III, fig. 4*a*, *b*.

This species is the largest among those contained in the nodules, and is even larger than the *Serpulites indicus*, W., of the lower productus-limestone.

The tube shows a gentle curve and must have been of very great length, as the fragments at my disposal are but very little tapering. The transverse section is narrowly oval, but this shape has certainly been brought about for the greatest extent by compression; originally it has probably been nearly circular.

The substance of the shell is not very thin, and of a brownish purple colour. It is composed of a great number of single lamellæ which easily separate from each other. The shell must have been flexible to a certain degree.

The outer surface of the shell is covered by numerous waving lines or folds, which give a very characteristic appearance to it. The internal surface is quite smooth.

The present species is easily distinguishable from *Serpulites indicus*, W., described in Volume I of the present work, by its size and by the neat ornamentation of the surface of its shell.

The same characters serve also to distinguish it from *Serpulites warthi*, which will be described next following.

Serpulites undulatus was collected in several specimens at Dillur.

17. SERPULITES WARTHI, Waagen, Pl. III, figs. 5, 6*a*, *b*.

1886. *Serpulites warthi*, Waagen: Rec. Geol. Surv. Ind., Vol. XIX, p. 28, Pl. I, figs. 4, 5.

The species has been characterised formerly by me in the following manner:—

"Next to *Conularia lævigata* this is the most common species in the concretions. It belongs to that group of forms which bear no marginal thickenings, and is very nearly related to a species, *Serpulites indicus*, W., from the lower productus-limestone."

From this latter species the present one is distinct by its much smaller size.

This group of forms, without marginal thickenings, has, till very recently, not been known to occur above the silurian period; but the species from the produc-

tus-limestone demonstrates that such species can occur also in much more recent strata.

The size of the species is still considerable, though it is much inferior to that of the previously described form. The transverse section is also compressedly oval, and the whole tube has a gentle curve. The surface is smooth without any ornamentation, and the shell, when well preserved, shining.

The species is distinct from the preceding one by its smooth surface and smaller size.

The horizontal distribution of the species is considerable, having been found at different localities from the Nila-Wan to Chél hill and Dandot.

18. (?) Serpulites tuba, Waagen, n. sp., Pl. V, fig. 16*a*, *b*.

1886. *Serpulites tuba*, Waagen: Rec. Geol. Surv. Ind., Vol. XIX, p. 28.

This is a very small species of rather peculiar appearance.

Only a small part of the tube, just the end with its trumpet-shaped aperture, is preserved in the Salt-range collection.

The shell seems to have been calcareous and not horny, and thus it is doubtful whether its position in the genus *Serpulites* is the right one. I thought whether it could not perhaps better be placed in the vicinity of *Dentalium* or the like; but the shell is so extremely thin that such a position appears very doubtful.

As such I place it, with a query, under *Serpulites*.

The tube is rather thin, apparently quite straight and with a circular section. Towards the mouth it suddenly widens considerably and terminates at the mouth with a sharp margin.

The surface of the shell appears to be perfectly smooth.

The species was collected by Dr. Warth at Dillur.

A second set of fossils belonging to the lower division of the speckled sandstone is composed of those species that are contained in the green sandstones, following immediately above the boulder bed in which the *Conularia* nodules with the above fanna were detected.

Whether these fossiliferous beds really belong to the speckled sandstone group and are be placed on a level with the green sandstones that were known to exist above the boulder beds of the Western Salt-range has for a long time been very doubtful, so much the more, as the *Conulariæ* were considered as occurring not *in situ*. Now that I have succeeded in determining the species, there cannot remain any doubt that they belong to the same set of rocks as the beds containing the *Conularia* nodules.

The species are the following:—

FOSSILS FROM THE GREEN SANDSTONES ABOVE THE BOULDER BEDS.

Genus: EURYDESMA, Morris.

Mr. Morris, in Strzelecki's Physical Description of New South Wales, characterises the genus in the following manner:—

"Testa aequivalvis, suborbicularis, tenuis, ad umbones crassissima, areâ ligamenti elongatâ, latâ, feré omninointernâ, dente valvæ dextræ magno, obtuso, sinistræ inconspicuo, canali byssifero antico ex umbone ad marginem testæ decurrente; impressionibus muscularibus plurimis, parvis ex internâ parteé umbonis anticé decurrentibus.

"At first inspection I was disposed to regard this shell as a relation of *Isocardia*; a more careful examination of all the specimens I have seen has, however, compelled me to entertain different views. I have ascertained that it really belongs to the *Monomyaria*, and that it ought to be arranged very near to *Avicula*, from which I believe it is only to be distinguished by its ventricose form and the position of its great muscular impression, which, instead of being nearly central as in *Avicula* (including *Meleagrina*, Dam.), is placed anteriorly."

This description of the genus, which was drawn up more than 40 years ago, is so excellent that barely any remarks remain to be added. Only one point must be corrected, and this is the statement of the equality of the valves, for in reality these shells are always a little inequivalve.

But though the structure of the shell is thus exactly known in all its detail, yet it seems nearly impossible to assign any definite position to the genus in the system.

Dr. Stoliczka, in Volume III of the Cretaceous Fauna of Southern India, has placed the genus in the family *Tridacnidæ*, but it appears nearly certain that such a position is not the right one. Dr. Stoliczka founds his opinion chiefly on the supposition that there existed a gaping lunette in front of the beaks, which gape served for the passage of the byssus. Now, in reality, there does not exist a trace of such a gape, the valves being perfectly closed in front in the manner figured by Dana in *Eurydesma globosum*, Dan., a little wing projecting from the left valve and fitting into a rounded emargination of the right one. Nevertheless a byssus was present, but this passed out by a narrow slit that extends from the apex of the right valve down to the cardinal margin just in front of the emargination of which I have just been writing and in front of the large tooth that exists in this valve.

Here I must give a little correction of Mr. Morris' diagnosis. In this diagnosis, the words "canali byssifero antico ad marginem testæ decurrente" give the impression that such an incision for the passage of the byssus was existing in both valves, whilst there is not a trace of it in the left one which bears the little wing instead.

Another thing which is not stated in Mr. Morris' diagnosis of the genus is the inequality of the valves, which is, it must be confessed, never very striking, and often barely perceptible; but which yet is a character that is always present.

These peculiarities must have escaped Dr. Stoliczka's notice, who evidently had no genuine specimens at his disposal, though some of them have been mentioned already by Dana.

If we take all these peculiarities into consideration, it becomes very doubtful whether the genus should be placed in the family *Tridacnidæ;* and one becomes inclined to accept rather Mr. Morris' view, who placed the genus somewhere near *Avicula*.

I myself had been led to a similar opinion in working out the characters of these shells from the Salt-range without yet knowing to what genus they should be attributed. All characters which one after the other were developed by me out of the rock seemed to point more and more to an affinity with *Avicula* or the like, more than with any other shell; and just this circumstance prevented me for a very long time from comparing these shells with *Eurydesma*, which genus had been placed in the *Tridacnidæ*.

The points of affinity with the *Aviculidæ* consist chiefly in the byssal incision being present in the right valve only; in the inequality of the valves, though the right one is the larger; and in the disposition of the muscular impressions, which are much like those in *Meleagrina*.

Notwithstanding all this, I am not in a position to positively assert that the genus should be placed in the *Aviculidæ;* but I should rather like to consider the question of affinity of the present genus as an open one.

The genus is at all events a highly peculiar one, and it seems not easy to mistake it for any other.

Up to the present, four species have been described of the genus; all which four occur in the Australian carboniferous deposits.

So much the more is it interesting to observe that three out of these four species occur also in the Salt-range in the olive and brown sandstones above the boulder bed containing the *Conularia* nodules.

1. Eurydesma globosum, Dana, Pl. VI, figs. 1, 2, 3, 4.

1849. *Eurydesma globosa*, Dana: United States Exploring Exped. Vol. X, Geology, p. 700, Pl. VII, fig. 7.

The general outline of the shell is obliquely transversely oval with a strongly prominent apical region and strongly inflated valves.

The anterior part of the shell is much more produced than the posterior one, and thus the apex is shifted far backwards. If we commence the special description of the outline at the apex, we find that this latter is very narrowly rounded, very strongly prominent, and not very much bent over. Anteriorly it shows a distinct emargination in the strongly sloping outline which corresponds to a kind of lunula,

situated in front of the apex and very deeply excavated. From these the outline descends in a gentle convex curve to the perfectly rounded, semi-circular anterior margin of the shell. This passes gradually without interruption into the lower or ventral margin, which is again gently arched. The posterior margin is more narrowly rounded than the anterior one, and is followed above again by a deep emargination corresponding to a posterior lunula, which is, however, less deeply excavated than the anterior one.

The external surface of the shell is provided with concentric striæ of growth, which are, however, owing to the rather bad preservation of the Indian specimens, rather indistinct.

The most important part of the shell is beyond doubt the hinge. It is rather difficult to describe this part, as its development is such a peculiar one that the mode of description generally adopted with regard to the hinges of bivalves will not hold good in this case. It appears to me that the whole hinge apparatus can only be explained by comparing it to the same parts of *Avicula*, *Pseudomonotis*, *Ancella*, etc.

Several cases have already been described in which the wings, characteristic for the *Aviculidæ*, are not spread out in the same plane as the valves, but in which they are more or less bent inside. I need only quote here the genus *Ancella*, of which lately Mr. Lahnsen has given an excellent description, or the genus *Liebea* described by myself, in which the anterior wings are deformed and bent inside in such a way as to be barely recognisable as such.

Starting from such considerations, we can now proceed to describe the hinge apparatus of the present species.

In the right valve, the most conspicuous part is a strongly prominent blunt tooth which originates just below the apex and extends a good way out in a nearly horizontal direction. It is perfectly solid in every direction owing to the enormous thickening of the shell substance in the apical region. At its extremity, this blunt tooth is a little compressed in a vertical direction and thus more or less spoon-shaped. In front of the tooth there extends a deep furrow in a somewhat curved line from the apex to the margin of the shell, where it causes a narrow slit to be formed, just in front of the termination of the tooth. Yet more forward (in front of the furrow) there extends the deeply excavated anterior lunula, characteristic of the genus, and reaching half way down to the anterior margin of the shell.

If we examine the space between the termination of the tooth and the apex more accurately, we find that immediately below the apex there originates a sharp but not very deep furrow, which extending in a somewhat sloping direction backwards gets by degrees shallower and broader and has evidently served for the insertion of the ligament. This furrow is limited below by a ridge which is highest just below the apex and becomes here tooth-like. It extends not very far backwards, but disappears after a short distance. It is somewhat more sloping in its direction than the furrow which has been described above. Yet further down from the apex and more approached to the termination of the blunt tooth is a deep, smoothly rounded

semi-elliptical excavation. The blunt tooth itself slopes on its posterior termination with gentle curve down to near the termination of the ligamental groove.

The different parts of this hinge apparatus can without great difficulty be explained by comparing them to similar parts in the right valve of *Ancella*. The deep furrow in front of the apex is the byssal furrow, which bears at its lower extremity the slit for the passage of the byssus. The blunt tooth behind this furrow can barely be explained otherwise than by the supposition that it represents the little wing of the right valve of *Ancella*, in this case entirely bent inside. The excavation on the upper part of the tooth serves for the reception of the anterior wing of the left valve, as we shall see presently. The sharp oblique ridge just below the apex and the ligamental furrow must, to all appearances, be considered as a real cardinal tooth.

The hinge apparatus of the left valve is considerably simpler. In front of the apex there extends here a large smooth well-excavated lunula, the cardinal margin of which projects vertically strongly in a semi-elliptical curve, and reaches with its upper termination to near the apex. Just below the apex there is a deep furrow, which bifurcates in the direction backwards. The lower somewhat more sloping part serves for the reception of the ridge-like sloping cardinal tooth of the other valve; whilst the upper part becomes gradually broader and has evidently served for the insertion of the ligament. Below and somewhat in front of the semi-circular prominence of the cardinal margin of the lunula, there is a shallow groove into which fits the flattened spoon-shaped termination of the blunt tooth of the other valve, not as the teeth of the hinges of bivalves generally do, but only being laterally pressed against this groove, whilst the vertically projecting margin of the lunula, which forms a kind of wing, accommodates itself in the excavation which is exhibited by the upper part of the blunt tooth. The byssal furrow of the right valve is thus left free by the other valve, which thus gives room for the passage of the byssus.

I cannot but compare this very complicated hinge apparatus with that of *Ancella*, though also here the similarity is only a distant one.

Of the muscular impressions nothing can be observed in any of the specimens of this species at my disposal.

The identity of the present form with Dana's species cannot be questioned, and it needs only a comparison of the respective figures to become convinced of it. The Indian shell has in some cases grown somewhat larger than Dana's originals, as is chiefly demonstrated by the fragments of which I have made the hinge preparates.

The best preserved specimen, a left valve, shows the following dimensions :—

Entire height of the shell	65	mm.
„ length „ „	67	„
„ thickness „ „	21	„
Apical angle	88°	

Up to the present the species has been detected only at one locality of the Salt-range, at Sadowal, where specimens of it were collected by Mr. Wynne and myself.

Dana describes the species from Ilawara, New South Wales.

2. Eurydesma ellipticum, Dana, Pl. VI, figs. 5, 6; Pl. VII, figs. 1, 2; Pl. VIII, figs. 1, 2.

1849. *Eurydesma elliptica*, Dana: United States Exploring Expedition, Vol. X, Geology, p. 700, pl. 7, fig. 6, a, b, c, d.

The outline of the present species is very distinctly transversely oval, with inflated valves, and a not very strongly prominent apical region. The anterior part of the shell is very strongly produced, the posterior one rather shortened. The apical angle is very large, as much as 107°.

The two valves are not equal in size, the right one being perceptibly larger.

The apex of both valves is tolerably broadly rounded, with a tolerably broadly strong emargination in front, corresponding to the anterior lunula. From there the cardinal margin passes gradually with a gentle convex curve into the anterior margin, which is very broadly rounded, and joins directly the broadly arched ventral margin. The posterior margin is somewhat more narrowly rounded. The posterior lunula is not very distinctly developed.

The surface of the valves is in all the specimens at my disposal too badly preserved to exhibit any sculpture. It is, however, probable that nothing but some concentric striæ of growth were existing.

Whilst in the preceding species the preparates of the hinge were so much broken that, though I was in a position to observe every part in working it out of the rock, yet the whole was in too fragmentary a condition to give exact figures of both valves; this is not the case in the present form. The figures represented on Plates VI and VIII give a fair idea of the hinge apparatus of both valves.

The hinge is very much like that described in the preceding species; only that according to the larger apical angle, every part is developed more in breadth. The specimen from which the figure of the left valve has been taken was evidently exposed for a long time to the rough treatment of the waves on a surf-beaten beach before being enclosed in the rock. It is strongly rolled and the little anterior wing into which the lunula is drawn out has for its greater part disappeared. Nevertheless the specimen is an instructive one, as I have succeeded in developing also the internal cast of it for its greater extent, which shows the very peculiar muscular impressions in a most beautiful manner.

There is one rather large but very flat muscular impression of a rather roundish shape not far from the centre of the valve, being however yet considerably posterior in its position from a line drawn from the apex to the middle of the ventral margin. Besides this large muscular impression there is a number of smaller but much deeper ones, which are arranged in a curved line from the anterior part to near the apex, and from there again descending for a short distance in the direction of the posterior part.

Towards the anterior region, several of them are united, forming on the cast a high crenulated crest. Then follow, somewhat lower in position, three or four single ones. At the apex the line makes a sudden bend and then follows again

one large impression, with which the whole succession terminates, not far from the posterior margin of the large muscular impression described above.

Whether there exists also an anterior muscular impression near the anterior termination of the row of small impressions cannot be distinctly seen, but traces of it seem to be present.

The whole arrangement agrees exactly with what has been described and figured by Morris and Dana, and recalls to a certain extent the characters exhibited by *Meleagrina*.

The materials of entire valves of this species are very limited, and thus I am not in a position to give exact measurements. In general, these can be seen from the drawings on Pl. VII.

The similarity of the Indian form to the Australian species is a striking one, and the only difference that might perhaps be adduced is a difference of the apical angle, which is indicated by Dana as 124°. If we compare, however, Dana's drawings we soon find that this apical angle is only to be found in the smaller valve, whilst in the larger one it is not more than 105°.

The species was collected by Mr. Wynne and myself at Sadowal. Dr. King and Mr. Middlemiss found a specimen of it, an internal cast, at Dandot in a bed of sandstone intercalated with the uppermost strata of the boulder beds containing *Conularia* nodules.

In Australia the species was collected by Dana at Harpur Hill, New South Wales.

3. Eurydesma cordatum, Morris, Pl. VIII, figs. 3, 4.

1845. *Eurydesma cordata*, Morris: in Strzelecki's Physical Description of New South Wales, p. 276, Pl. XII.
1849. *Eurydesma cordata*, (Morris) Dana: United States Exploring Expedition, Vol. X, Geology, p. 700, Pl. VIII, fig. 1.

The original figure of this species by Sowerby in Sir T. Mitchell's Expeditions into Australia is not accessible to me, and the figures given by Morris in Strzelecki's work are a great help towards the recognition of the genus; but as to species it is barely possible to recognise anything from them. So far the definition of *Eur. cordatum* and the figure given in Dana's work is of the greatest importance. Unfortunately, however, Dana himself is not quite sure whether his drawing represents really Morris' species.

I am not in a position to decide the question: I can only compare the specimens from the Salt-range here under description with Dana's figure, and state that the general similarity seems to be a striking one.

The materials from the Salt-range are, however, rather limited and restricted to small young specimens.

The chief character of this species seems to consist in the nearly median position of the apex and the nearly circular outline of the valves.

Both these characters are strikingly exhibited by a small left valve and an internal cast collected by Dr. King and Mr. Middlemiss.

The left valve is not more than 36mm. in height and 38mm. in length. The apical angle is 113°. The thickness is rather small, being not more than 12mm.

The apex is tolerably prominent, but not distinctly marked off from the remainder of the shell. It is well bent over and pointed. In front of it there is a quite shallow emargination corresponding to the anterior lunula. The anterior part is slightly more narrowly rounded than the posterior one; otherwise, however, as bas been stated above, the outline is nearly circular.

The surface of the shell is very badly preserved and seems to be smooth, with the exception perhaps that there exist some indistinct concentric striæ of growth. Of a radial striation, as it has been described by Morris, not a trace is visible, but this seems also to be the case in Dana's original, where such a striatiou is mentioned only at places on the internal surface of the shell, or in the internal shell-structure. As to the latter point, the Indian specimens are absolutely hopeless, the shell-substance being in all cases converted into crystalline calcspar.

In this specimen the hinge is also tolerably well preserved, though much disfigured by adhering grains of sandstone, which have been caught in the crystallisation of the calcspar. There is, however, the little wing, characteristic of this valve clearly visible; also, the groove for the insertion of the ligament can be well distinguished. The anterior lunula is not very deeply excavated, the posterior one is barely at all developed.

The internal cast from Dandot is rather indifferently preserved, and it remains doubtful whether it has been rightly placed by me in this species. The impression of the hinge that remains shows, however, clearly that this specimen belongs to the genus *Eurydesma*. On the surface of this cast traces of muscular impressions can be made out, though they are rather indistinct. There is one large impression posteriorly and perhaps a small one anteriorly. Between the two there are numbers of small deep impressions, as they have also been described in *Eur. ellipticum*.

Of the two specimens from the Salt-range that I attribute to this species, the one has been collected by Mr. Wynne at Sadowal, the other by Messrs. King and Middlemiss at Dandot in the same bed in which also *Eurydesma ellipticum* described above has been found.

In Australia the species is quoted by Morris from Ilawara and by Dana from Harpur's hill, both in New South Wales.

4. (?) Mæonia gracilis, Dana, Pl. VIII, fig. 5.

1849. *Mæonia gracilis*, Dana: United States Exploring Expedition, Vol. X, Geology, p. 698, pl. 7, fig. 1*a*, *b*, *c*.
1876. *Mæonia gracilis*, (Dana) Koninck: Foss. Paléoz. de la Nouvelle-Galles du Sud, Vol. II, p. 281, Pl. XIX, fig. 1.

It is with great doubt that I introduce this name for one of the shells of the Olive group, which is certainly different from *Eurydesma*, as it possesses an entirely external ligament, but of whose internal structure I know otherwise nothing.

The rock in which the specimen is contained is so extremely hard and com-

pacted with the fossil, that every attempt to make the hinge visible was absolutely in vain.

Thus, there remains nothing but the general outline and the external ligament according to which this shell must be determined.

The general outline reminds one to a certain extent of the genus *Mæonia*, Dana, and thus I was led to compare the shell to the species belonging to that genus. Among these the *Mæonia gracilis*, Dana, bears the greatest resemblance, and thus I quote this shell under that name.

It is a well-sized species to which the specimen belongs. The general outline is somewhat triangular with a broadly rounded anterior and a very strongly produced posterior part. The apex is prominent, rounded, and well bent over. Just below the beak above the hinge-line there is a deep furrow for the insertion of the ligament. The hinge area is narrow and not well defined. In front of the beak there is an excavated but not sharply defined lunula. The anterior margin is broadly rounded and passes gradually into the ventral one, which forms a low arch. Where this latter joins the posterior margin, a rounded angle is formed. The posterior margin is short and nearly straight, joining the dorsal margin also under an obtuse angle, whereby an indistinct posterior truncation of the shell is effected. The dorsal margin is but very slightly arched and ascends obliquely to the beak.

The shell is, on the whole, rather strongly and equally vaulted. From the apex to the lower posterior angle there extends a kind of very obtusely rounded ridge, from which the surface descends somewhat more rapidly towards the hinge-line.

The ornamentation of the surface is nearly entirely destroyed by weathering. It seems to have consisted of rather coarse striæ of growth.

The dimensions of the single specimen, a right valve, known to me, are as follow :—

Entire length of the shell	91mm.
„ breadth „	75 „
„ thickness „	25 „
Apical angle	97°

The determination of this species is by no means certain, but among the shells to which the Indian specimen could be compared, *Mæonia gracilis*, Dana, seemed to be the most similar one.

Mr. Wynne found the Indian specimen at Sadowal.

Dana describes the species from Wolongong point, district of Illawara; and M. de Koninck mentions it from Murree.

With this species the number of forms hitherto detected in the lower division of the speckled sandstone is at an end.

We have now found that three different horizons within this division have proved fossiliferous. These horizons are the following :—

The lowest one has been observed Trans-Indus only. It consists of the black

shales at the base of the boulder beds there, and has furnished, as has been mentioned above, the following three species:—

Hyolithes orientalis, W.
„ *sp. indet.*
Cardiomorpha indica, W.

The second one has proved, up to the present, most fossiliferous and at the same time has the greatest lateral extension, though it is not everywhere provided with fossils. It consists of the much spoken of boulder beds, and the fossils are contained in nodules. The species that have been found in these beds belong to the following species:—

Pleurotomaria nuda, Dana.
Bucania warthi, W.
Conularia lævigata, Morris.
„ *tenuistriata*, M'Coy.
„ *warthi*, W.
Sanguinolites cf. *mitchellii*, Koninck.
„ *tenisoni*, Koninck.
Nucula sp. indet.
Pseudomonotis subradialis, W.
Aviculopecten cf. *limæformis*, Morris.
Spirifer vespertilio, Sow.
Martiniopsis darwini, Morris sp.
Chonetes cracowensis, Eth.
Discina sp. indet.
Discinisca warthi, W.
Serpulites undulatus, W.
„ *warthi*, W.
„ *tuba*, W.

Altogether eighteen species. A peculiar character of this fauna is that all the species are of comparatively small dimensions. The very frequent occurrence of specimens of *Discina*, *Discinisca*, and *Serpulites* point to a muddy beach where these deposits have been formed, whilst the single valves of all the *Pelecypoda* and the remaining *Brachiopoda* point to the circumstance that these latter forms have not lived on the spot, but were transported thither from a distance before they were imbedded.

Of the species quoted there are nine identical with forms that have been described previously from the carboniferous deposits of Australia. These are—

Pleurotomaria nuda, Dana.
Conularia lævigata, Morr.
„ *tenuistriata*, M'Coy.
Sanguinolites cf. *mitchellii*, Kon.
„ *tenisoni*, Kon.

Aviculopecten cf. *limæformis*, Morr.
Spirifer vespertilio, Sow.
Martiniopsis darwini, Morr. sp.
Chonetes cracowensis, Eth.

This is just half the number of all the species detected up to the present in these deposits. The other half consists of species which are either new to science or else they are not distinctly determinable. This latter half consists of the following species :—

Bucania warthi, W.
Conularia warthi, W.
Nucula spec. indet.
Pseudomonotis subradialis, W.
Discina spec. indet.
Discinisca warthi, W.
Serpulites undulatus, W.
„ *warthi*, W.
„ *tuba*, W.

Of these, *Bucania warthi* and *Pseudomonotis subradialis* appear very nearly related to species occurring in somewhat higher beds of the Salt-range series. The former is very nearly allied to *Bucania kattaensis*, W., of the upper speckled sandstone or lower productus-limestone group, whilst *Pseudomonotis subradialis* stands in a similar relation to the permian species *Pseudomonotis radialis*, Phill., occurring in the upper productus-limestone.

The case is different with *Conularia warthi*. The nearest relation to this species is *Conul. quadrisulcata* of the lower and middle carboniferous of Europe.

On the whole, it must be admitted that the fossils of the *Conularia* nodules show an intermingling of European and Australian carboniferous types; but that, though this is the case, there has not been detected a single form which would not be in accordance with the one fundamental fact that all the forms point unanimously towards a carboniferous age of the beds in which they were contained. This fact alone makes it impossible to accept the view that the nodules had to be considered as in a secondary position, and that the boulder beds in which these nodules occur were thus to be accepted, notwithstanding these fossils, as of cretaceous age. It has been pointed out already by W. T. Blanford that in such a case it would be inexplainable how the fauna of the nodules was such an exclusively carboniferous one and at the same time of such a peculiar character; for one must suppose that the nodules were all taken out of one and the same bed, a thing which seems nothing less but improbable, considering the very mixed character of the boulders which are contained besides the nodules in the bed.

Now, there has been detected a direct proof for the occurrence *in situ* of the *Conularia* nodules, in the fauna that is contained in the green sandstones that follow immediately above the beds with *Conulariæ*. These sandstones from the highest

fossiliferous horizon within the lower division of the speckled sandstone and have furnished the following species :—

Eurydesma globosum, Dana.
„ *ellipticum*, Dana.
„ *cordatum*, Morris.
Mæonia gracilis, Dana.

Though there are not more than four species, yet these are of the utmost geological interest, as every one of them can be identified with an Australian species; as well as with the most striking and most peculiar types of the whole Australian carboniferous. There has never existed the slightest doubt about these Olive-group bivalves being *in situ*, and thus it can also not be doubted that the beds in which these species occur must be considered as about on the same horizon as the similar beds in Australia, which have furnished the same species. There is no intermingling here with European types, but the whole is thoroughly Australian. This is up to the present the only place in the world where a typical Australian assemblage of species has been detected outside the continent of Australia; and as these beds are associated with others, in which the European and North American type of development of the carboniferous strata prevails, this point will be of the greatest importance for the exact determination of the age of the Australian carboniferous in comparison with that of other parts of the world.

Now even Dr. Feistmantel, who has dwelt recently (Sitzungsber. Kön. böhm. Geo. d. Wissensch, 1887) with much satisfaction on the mistakes I have made with regard to the *Conularia* nodules, will be compelled to admit the importance of the occurrence of an Australian carboniferous fauna in the Salt-range, of a fauna from which there is no escape but to consider it *in situ*, above the much contended boulder beds; and he will also be compelled to admit the fundamental bearing this has on the solution of the most important questions with regard to the real age of some of the Indian peninsular deposits.

For such a solution it will also not be useless to note the character of the rocks in which these bivalves occur, which are of two different kinds. Some of the specimens are contained in a brownish quartzitic breccia or coarse sandstone which sometimes passes into a conglomerate. This rock is of excessive hardness, and it is only by chance that one or the other better-preserved specimen can be worked out, when also it is found that the shells are much worn and rolled.

The majority of the specimens, however, are preserved in a finely grained greyish-green sandstone, which also sometimes contains larger pebbles. The fossils are all converted into crystalline calcspar which is compacted with the rock substance, and they are of the brittlest kind imaginable. The greenish colour of the sandstone is caused by the cement of the rock being a greenish clay stuff, resembling much a very fine volcanic ash, the exact nature of which however cannot be determined. The prevalence of lime in the rock seems to point to Diabase.

It is now very interesting to compare what Dana says with regard to the rock exposed at Harpur's hill. He says: "At Harpur's hill the rock is a bluish or

greenish compact sandstone, not at all schistose, containing an occasional pebble of greenstone, amygdaloid, or granite. Much of it is composed of fine earthy grains, as if from the decomposition of greenstone; there is rarely the glistening lustre derived from grains of quartz. Some portions of the rock contain carbonate of lime sparingly disseminated; but this is mostly confined to the layers in which the fossils are most abundant. The fossils themselves are calcareous instead of siliceous." This description looks nearly as if it had been drawn up from Indian rock specimens.

Quite similarly Dr. A. Schenk, who has recently returned from South Africa, characterises the rock which accompanies the Dwyka conglomerate there. (Verhandl. d. Deutsch. Geographentages, 1889, p. 152.)

Thus it seems that even the minute structure of the rock, as it is found in these beds in India, shows characters which in many ways recall similar rocks occurring on a similar horizon in Australia and Southern Africa.

The chief point in this respect consists, however, always in the striated pebbles which are found sometimes in great numbers in the boulder beds properly speaking. At most localities where the boulder beds are exposed, striated pebbles occur, but mostly in limited numbers and without polished surfaces. At some places, however, chiefly in the Eastern Salt-range, these pebbles are heaped together in great numbers and show a peculiar character, which does not, or only very rarely, occur at other localities, and this character consists in these pebbles showing many polished facets, all exhibiting a glacial striation. The glacial origin of these pebbles has been much contested; and as it is also for the palæontologist of very great importance to see clear in this matter, I have figured one of these pebbles on Pl. III, fig. 3*a*, *b*.

The pebble consists of red porphyry and shows a number of facets, on all of which a striation is very distinctly visible. On the largest facet, striation in three different directions can be distinguished. The greatest number of striæ shows a direction from right to left; second in number, striæ are observable which are directed from the right below to the left above, that is to say, in a diagonal direction; a few at last are directed a little obliquely from above downward. The facets on this pebble are numerous, about fifteen in number, and three different series of them can be distinguished. Each of these series corresponds to a different axis of revolution, of which there are three present. If we bring one of these axes into a vertical position, the second cuts this first one under an angle of 45°, and the third cuts the first under an angle of 80°, and the second under an angle of about 35°. Then belong to the first axis of rotation three small facets which are not distinguishable in the figures, and the nearly vertical striæ in fig. 3*a*. To the second axis belong the obliquely ascending striæ on the large facet of fig. 3*a*, and the two small facets to the left above it, as well as the large medium facet in fig. 3*b*. To the third axis belong the two narrow facets on the left side of fig. 3*b*. and a number of smaller ones, which are hidden in the dark shade of the same figure, as well as the horizontal striation on the large facet of fig. 3*a*.

All this shows that such a pebble was very often shifting its position, but that

it was retained in certain positions for a more or less long period, whilst in others it remained only for a comparatively short time soon shifting again into another position. Sometimes the change of position was a radical one. On the whole, the kind of movement was generally a rolling one, though the rotation must have been very slow, and arrested for longer or shorter intervals at different times.

These facetted pebbles will always be a very remarkable feature of these deposits, and I must confess that I have never observed either in the moraines of actual glaciers nor in those of the quaternary period pebbles exhibiting similar characters. It is already rare to find a pebble with a single facet polished and striated, much less stones with several facets. These polished facets show, however, a very great similarity to the polished facets exhibited by the bottom rock over which a glacier has moved. The rocky bed of an old glacier shows numbers of such ground-down places, which are all beautifully striated. If we now try to find out what may be the reason that fragments so seldom show such ground-down facets, whilst such are of very frequent occurrence on the bottom rock of the glacier; the simplest explanation seems to be, that the bottom rock is exposed for a long continued time to the action of the glacier, whilst the fragments transported by the glacier are carried their way and then discharged. So the chief reason for the rareness of such facetted stones seems to be, that the way which these stones are carried along in the ground moraine is too short in the glaciers of the present days to produce facetting. Thus we come to the conclusion that if the form of the facetted pebbles of the Salt-range is due to ice-action, these stones must have been carried along under a very high pressure over enormous distances on the under-side of an ice-stream to become shaped in such a manner as we find them now.

The question that remains to be solved is: Were these pebbles shaped by ice-action? The question has already been much discussed by the British Association for the Advancement of Science, by Mr. W. T. Blanford, by Mr. R. D. Oldham, etc., and more recently in a most exhaustive manner by Prof. G. H. Stone. In his most important paper published in the Geological Magazine for September 1889, the latter observer comes to the conclusion that the only way in which scratches and facets like those exhibited by the Salt-range pebbles have up to the present been observed to be produced is by the action of glaciers. The possibility of similar features being also produced by floating ice, landslips, or fault-movements, cannot be denied; but no observations have been made in this direction up to the present. Thus, though the question seems not yet to be solved absolutely, there seems to be a great probability of these facetted pebbles having been produced by the action of glaciers or, at all events, by the action of ice. This becomes so much the more probable as traces of ice-action have also been observed in other countries in beds of a similar age.

The beds in which these pebbles occur in the Salt-range are, however, beyond doubt of marine origin, as is proved by the *Conularia* nodules with marine fossils, as well as by the occasional interstratifications of beds of sandstone with specimens of *Eurydesma* which are also marine species. Thus it appears barely credible that the boulder beds should be real moraines: it is by far more probable that the materials

of glacial origin were transported thither by floating ice-bergs that were drifted from the south, after they had been broken off there from some widely extending glacier, coming down to the level of the sea.

Having thus ascertained all the features of importance with regard to the lower division of the speckled sandstone, we can now proceed to compare it with the deposits existing in other countries.

According to the general plan retained in this work the countries which are least remote ought to be first taken into consideration. In this case, however, such a proceeding appears inadvisable, as the greater part of the fossils contained in these beds points to an affinity with Australian deposits; and thus by the nature of things we are in the first place led to compare the Salt-range strata with those of Australia.

In Australia four different districts can be distinguished according to the different development the single sub-divisions of strata exhibit. The one that has been made known most in detail is in New South Wales. Another not quite so well known area is situated in Victoria; and a third area is the Tasmanian one. A fourth area is composed of the deposits known to occur in Queensland.

The most recent publications on Australian geology in general are by Dr. Feistmantel, published in the "Sitzungsberichte der kön. böhm. Gesellschaft der Wissenschaften." It is only to be regretted that these most important publications are less dictated by the wish to elucidate the very intricate questions with regard to Australian geology than by the desire to defend the author's views with regard to a parallelisation of these deposits with similar beds in India: and thus many a point which would be of very great interest is treated only *en passant*. The greatest thanks of the scientific public are, however, due to Dr. Feistmantel for his having collected the local Australian literature on the subject, which is in general very difficult of access and yet contains very important information. Some papers have, however, also escaped his notice; as Dana's very important report on the geology of New South Wales and the paper of R. Etheridge, Junior, on the Bowen river coalfield, etc.

It cannot be my purpose to enter here on all the controversies as to how the different deposits in the single areas above mentioned should be correlated with each other. The decision of these points must be left to the local geologists who have made detailed studies on the spot.

What can be gathered from the Australian literature with regard to the beds that especially interest us here is about the following:—

In most of the Australian territories the base on which rests the carboniferous formation is formed by devonian beds, which have, however, not been determined in all cases with sufficient certainty as such. In Tasmania the soft shales of Fingal and the fresh-water beds with *Anodonta gouldi* are considered as devonian. In New South Wales devonian beds have been observed at several localities, and in Queensland the Burdekin river and Fanning river limestones have been recognised as devonian by R. Etheridge, Junior.

In what manner the carboniferous formation follows above the devonian strata

is in most cases yet very uncertain. In some cases, truly lower carboniferous beds seem to intervene, but at others such seem to be absent.

In Tasmania, for instance, in the Mersey coalfield, there seem to follow immediately above the soft devonian shales marine beds which must be considered according to Mr. Johnston's indications, who quotes *Stenopora*, *Strophalosia*, etc., in these beds, decidedly as upper carboniferous or permo-carboniferous. In Victoria, on the contrary, Mr. M'Coy quotes as well beds with—

Ancimites iguanensis, M'Coy,
Archæopteris howitti, M'Coy,
Cordaites australis, M'Coy,
Sphenopteris iguanensis, M'Coy,

as of devonian age; as he also considers other beds with *Lepidodendron australe*, M'Coy, from the Avon river as representatives of the lower carboniferous. Higher follow, whether discordant or not is not known, the Bacchus Marsh sandstones which contain a great glacial conglomerate. There is apparently not a trace here of the marine fauna quoted in Tasmania.

In New South Wales the case is again different. Here follow, above the devonian, beds with *Lepidodendron*, *Cyclostigma*, *Rhacopteris*, *Calamites*, &c., and a marine mollusc fauna, which are considered by Dr. Feistmantel as an equivalent of the lower carboniferous. The fauna has apparently never been described, as in the work of M. de Koninck there have been figured barely any species of molluscs, which one is wont to find associated with lower carboniferous plants; nearly everything in that work representing much more recent types. The great bulk of the specimens that have served for de Koninck's descriptions, sent to him by the Rev. W. B. Clarke, has evidently come from the next higher division of the carboniferous there; and it is only to this fauna described by Koninck that the Salt-range fossils can be compared.

In Queensland there follow above the decidedly devonian Burdekin river limestone, sandstones which are probably yet of a devonian age. Next in the sequence comes the Star river series, a very doubtful assemblage of rocks, which seems to comprise some devonian (Mount Wyatt) and lower and upper carboniferous beds. Mr. Etheridge, Senior, had considered these beds as devonian, but the greater number of fossils that have been collected up to the present, among them *Productus cora*, Orb. (the typical form), point to an upper carboniferous age.

Thus, we have seen that the basal rocks on which the beds containing the rich carboniferous fauna of Australia rest are generally of a devonian age; whilst at places a truly carboniferous series seems to be present, though with this the basal rocks come everywhere to a close.

Whether now the fossiliferous beds of the upper series follow conformably above the basal rocks or not, is not known with certainty. At all events a break must exist, as the upper part of the upper carboniferous (the true carboniferous coal-measures partly or entirely) seems apparently to be absent.

This upper series is composed nearly everywhere in the following manner from above downward, excepting the most recent beds, which will be treated of later on in the text:—

Upper coal-measures (Newcastle beds).
Upper marine beds.
Lower coal-measures.
Lower marine beds.

Basal rocks.

This sequence of beds holds good for New South Wales, as well as for Tasmania (Mersey coalfield); whilst in Victoria only representatives of the lower marine beds and perhaps lower coal measures exist, and in Queensland the upper carboniferous; part of the Star river series must perhaps be placed approximately on the same level as the lower marine beds.

This whole sequence of rocks can be divided most conveniently into two large series: one lower, containing marine fossils and some intercalated coal seams, also associated with marine fossil species; and one upper, containing, at least in New South Wales, no marine fossils, but a great many coal seams with associated plant-remains (upper coal measures, Newcastle beds). In Tasmania, apparently, the marine fossils extend into higher beds, and Dr. Feistmantel parallelises part of the upper marine beds and lower coal measures there with the Newcastle beds of New South Wales, whereby neither the true lower coal measures nor the true upper coal measures would be represented, but both would be replaced by marine deposits.

Howsoever this may be, it does not much matter for our present purposes.

The marine fauna contained in the lower series, which at present interests us most, has never been worked out in detail. The only larger work that has been published with regard to these things is the one by M. de Koninck. It is, however, much to be regretted that this work is not of much use for geological purposes for two reasons: first, because the limits drawn for the different species are so very wide that no geological conclusions can be based on these determinations; and second, because the materials that have served for description had not been collected according to sharply defined geological horizons.

Thus we know up to the present nothing about the changes the marine fauna has undergone in Australia during the time of deposition of the marine series; and the only thing is to treat these beds all as one whole, so much the more as the greater part of the species, according to the information at present available, seems to extend from the bottom to the top beds, and in Tasmania they seem even to ascend for a great part into the Newcastle beds.

The most useful paper towards a determination of the geological age of the Australian marine carboniferous strata has been published by R. Etheridge, Junior, in the Proceedings of the Royal Physical Society of Edinburgh for 1880. This publication is very difficult of access on the Continent, and it is only due to the great

kindness of W. T. Blanford, who procured me a copy of it, that I have been placed in a position to make use of it.

Mr. R. Etheridge, Junior, is the first writer on the subject who has drawn the attention of the scientific world to the fact that the genus *Strophalosia* is not at all rare in the Australian carboniferous deposits, and that the occurrence of this genus would be rather suggestive of a permian age for these strata. It is true that the distribution of the genus in the Australian carboniferous seems not to be an equal one; it seems to be most rare in New South Wales, from which district only a few specimens of *Stroph. inkesi*, Eth. Jun., and *Stroph. clakei*, Eth. sp., have been recorded. It seems to occur much more frequently in Tasmania, from which country it has been quoted by Etheridge, Jun., and Johnston. A real profusion of specimens of this genus occurs according to Etherige Jun.'s indications in the Bowen river coalfield in Queensland, which is to all appearances the most recent one of all the Australian coalfields, resting unconformably on beds with *Productus cora*, Orb. (lower marine beds), which is already a permo-carboniferous form.

Now in this marine series, as it has been circumscribed above, with the exclusion of the Bowen river coalfield, which is of more recent age and rests unconformably on it, all the species have been found which I have described in the preceding pages as occurring in the Indian Salt-range as well as in the Australian carboniferous deposits. Only *Chonetes cracowensis*, Eth., has been described originally from the Bowen river; but as in these latter beds also *Martiniopsis darwini* occurs, which is so frequent in New South Wales and Tasmania, it is evident that some of the lower occurring species extend even up into the Bowen river series. Thus, the *Chonetes cracowensis* does not cause much difficulty.

All the other species, twelve in number, point most distinctly towards the marine series of New South Wales and the lower marine beds of Tasmania as the equivalents of the strata of the Salt-range in which these fossils occur. A distinction of several beds, as we have accepted it for the Salt-range, cannot be retained, and thus the list of identical forms is as follows :—

Pleurotomaria nuda, Dana.
Conularia lævigata, Morr.
„ *tenuistriata*, M'Coy.
Sanguinolites cf. *mitchellii*, Kon.
„ *tenisoni*, Kon-
Mæonia gracilis, Dana.
Eurydesma globosum, Dana.
„ *ellipticum*, Dana.
„ *cordatum*, Morr.
Aviculopecten cf. *limæformis*, Morr.
Spirifer vespertilio, Sow.
Martiniopsis darwini, Morr. sp.

In the face of this rather extended list it can barely any more be questioned

that the Salt-range beds containing these species must be in a general way homotaxially identical with the marine series of the Australian carboniferous, as I have circumscribed it above; while this comparatively large number of identical species would alone quite suffice to prove such an identity. To this there comes, however, yet another fact pointing in the same direction, and this is the occurrence of traces of glacial action in these beds, the existence of which has been proved beyond doubt by Mr. R. D. Oldham, and afterwards confirmed by M. Wilkinson.

It will perhaps yet be remembered by some of the readers how startling a coincidence happened in this respect when we both (Mr. Oldham and myself) quite independently, without having the least idea of what each was about: the one stated the undoubted occurrence of traces of glacial action in the marine series of the Australian carboniferous, and the other recognised among the fossils occurring in the glacial deposits of the Salt-range species identical with those of the Australian marine carboniferous series, and how both came to the conclusion that these glacial beds ought to be placed on a level with the Talchirs of peninsular India.

The case was again obscured afterwards with regard to the Salt-range, as the occurrence *in situ* of the *Conularia* nodules was questioned. Now every doubt in this respect has been dispersed, after an Australian carboniferous marine fauna has been detected in the green sandstones following immediately on the boulder beds, concerning the genuine position of the fauna of which there can be no doubt.

With regard to a parallelisation of the Australian glacial beds with the Talchirs, even Dr. Feistmantel has yielded the point; and in his most recent publications he considers such a correlation as above all question. Chiefly with regard to the Bacchus-Marsh sandstone of Victoria, such a parallelisation is proved also by the plant-remains, by the prevalence of the genus *Gangamopteris* and some identical species; whilst with regard to the lower coal measures of New South Wales which form intercalations in the marine series with its glacial deposits, the similarity of the floræ is less striking, though also here a typical affinity cannot be denied. After however Dr. Feistmantel himself admits the great probability of the glacial beds of the Talchirs of India and those of the carboniferous of Australia being about on the same level, such a unanimity has been arrived at in this respect that it appears useless to waste more words on this point.

The Salt-range beds, the geological position of which had been questioned formerly, are now also proved beyond doubt as identical with the marine series of the Australian carboniferous; and thus it can also not be subject to much doubt that they must be an equivalent of the Talchirs of peninsular India, though plant-remains have so far not been found in the Salt-range deposits.

The chief rock on which such a parallelisation of the Talchirs with the Salt-range strata can be founded is the great boulder bed that occurs in the lower division of the speckled sandstone group, a very similar rock also due to glacial action occurring at the base of the Talchir formation.

The distribution of the Talchir boulder-bed, which has been recognised as of glacial origin as far back as 1859 by W. T. Blanford, is a very general one in the

different coal basins of peninsular India. For us, in the present case, it is, however, of special interest that traces of this boulder bed have been discovered by Messrs. W. T. Blanford and R. D. Oldham in the desert of Rajputana to the west of the Arvali-range. These boulder beds have been called directly Talchirs by Mr. R. D. Oldham, and it seems that there cannot be entertained much doubt about such a determination. This brings the Talchirs much closer to the Salt-range than any of the other peninsular rock groups, though also here the distance is still very considerable.

After all that has been said, it seems more than probable that the Talchirs and the lower division of the speckled sandstone must be considered as about on the same level.

Dr. Feistmantel in his most recent publications rightly points to the circumstance that though the glacial beds of the Talchirs might be on the same level as similar beds in Australia and Southern Africa, yet with this not the whole of the Talchir group has found its equivalents, and that it must not be forgotten that above the Talchir boulder beds a series of sandstones and shales is developed which contain a characteristic flora. It is not my business here to find out the equivalents of these upper beds of the Talchir group in Australia or Southern Africa, chiefly as this has been done already very ably by Dr. Feistmantel; but I must point to the fact that above the boulder beds of the Salt-range, which can be placed on a level with the Talchir boulder beds, there follows a series of green sandstones and some shales, composing the upper part of the lower division of the speckled sandstone group, which have also been proved as of upper carboniferous age, and which thus, homotaxially at least, must be considered as the equivalents of the Talchir shales and sandstones.

This is all that can be said with regard to the equivalents of the lower division of the speckled sandstone group in peninsular India.

In the Himalayas I cannot point out any beds, which, with some probability, could be placed on a level with the division here under consideration. The formations there are as yet too little known in detail. Only the so-called carboniferous deposits of the Kashmir valley may perhaps be on a similar level, as we shall see in the sequence.

North of the Salt-range, a boulder bed has been observed by me at Mount Sirban, which rests unconformably on the Attock slates. This might perhaps be compared to the Salt-range boulder bed, but I cannot say anything particular about the matter.

Outside of India and Australia it is well known that equivalents of these beds exist in Southern Africa. I cannot here again enter into the discussion of all the facts relating to such a parallelisation. These have been expounded already in detail in my paper on the carboniferous glacial period, and also by Dr. Feistmantel in the Sitzungs ber. d. kön. böhm. Gesell. d. Wissensch., 1887. Only one thing I should like to mention; this is, that according to the quite recent observations of Dr. Schenk there cannot be any question as to the glacial origin of the Dwyka conglomerate.

That glacial boulder beds which are apparently on a similar level occur also in Brazil is known by the observations of Prof. Derby of Rio de Janeiro.

We see from all this that as long as the glacial boulder beds hold good, it appears not too difficult to point out certain beds, which might be considered as equivalents of the glacial beds in India. These traces of glacial action are nearly everywhere accompanied by the appearance of a characteristic flora, containing *Gangamopteris*, *Glossopteris*, *Vertebraria*, etc.; and if a marine fauna is present, it bears the character of the Australian carboniferous fauna. Under such circumstances it is hardly possible to reject the idea that such characteristic peculiarities must be caused by climatic influences, a fact which has up to the present not been admitted to exist in carboniferous times. With regard to the plants the phyto-palæontologists seem even now to be very much averse to admit such a thing.

This peculiarity of development of the fauna and flora under glacial influences or at least under a very cool climate makes it nearly impossible to compare the beds here under consideration with others occurring in Europe, etc., which have apparently not been exposed to such influences. I shall discuss these relations later on in the text, if we have to compare faunæ of a European type with those of other countries. I may remark only that the exact age of the Australian deposits here under discussion with regard to the general standard of formations cannot be determined except by considering their relations to the sequence of rocks exposed in the Salt-range, where these beds are developed far below the truly permian strata.

Among the fossils described from the Australian carboniferous, two series are of geological importance: one consisting of a few species which can be picked out among the forms described by M. de Koninck, while others have a typically carboniferous aspect. As, however, the geological positions of the species described by de Koninck are not known, these might as well have been found in the series of beds in which also occur *Calamites radiatus*, *Lepidodendron dichotomum*, *Lep. veltheimianum*, *Lep. volkmannianum*, etc., which beds are also not devoid of marine fossils.

The other series, composed of species comparable to European ones, consists of much more recent types: *Strophalosia*, *Stenopora*, *Productus cora*, Orb., *Prod. aff. horrida*, etc. These must be natives of the marine series, as I have defined it here, as there are no other beds from which they can come. Thus, according to these few data, a position of the Australian carboniferous very high in the sequence of beds belonging to the carboniferous epoch in the widest sense as it has been circumscribed in Europe and elsewhere, appears the most probable one.

Another fact that applies, however, not only to the marine series here under consideration, but which is to be observed as well in the higher divisions of the Australian carboniferous, is the frequent occurrence of silicified trunks of trees, which for the greater part belong to the genus *Araucarites*. This fact has already been recorded by Dana, and has been confirmed afterwards by Etheridge, Jun., and Carruthers. This character reminds one strongly of similar facts occurring in the permian of Europe.

C. MIDDLE SPECKLED SANDSTONE.

It is not possible to give many indications with regard to the present sub-division of the speckled sandstone group, as it has been found up to the present to be entirely devoid of organic remains.

It follows everywhere above the lower division in quite a regular manner, and its composition varies but little.

It is distinct from the lower division by a change of colour. Whilst the upper beds of the lower division, where they are well developed, show a greenish or greyish colour, a red colour begins to appear with the commencement of the middle division. From the upper division of the speckled sandstone, it is less easily distinguishable; and often both blend in such a way together that they can be distinguished only by the circumstance that fossils occur in the higher beds, whilst they are absent in the lower ones.

The lower beds of this middle division are always composed of sandstones of often considerable thickness, in which the red colour generally prevails. These sandstones form the great mass of what has been called speckled sandstone by Mr. Wynne. Though in general aspect these sandstones appear mostly red, yet on a close examination they are often found to be speckled or greyish.

Towards the upper region there appear more and more frequently shaly intercalations, which are mostly of a lavender colour, but often also darkly grey to nearly black or also greenish.

The upper region of the middle division is nearly entirely composed of these "Lavender shales" as they have been called by Mr. Wynne. They are frequently interrupted by numerous intercalations of a grey or bluish, often concretionary marl stone.

This sub-group has been described by Dr. Warth in detail in the Eastern Salt-range in the country around mount Chél, where it follows above the green sandstones with *Eurydesma*. From there it can be followed towards the west over the greater part of the Salt-range proper. In the Nila-Wan it begins to be succeeded by the upper division of the speckled sandstone or lower productus-limestone. Towards the north it thins out, and in the country round Kalabagh nothing remains of the whole speckled sandstone except the boulder bed.

Whether the purple sandstones following trans-Indus above the boulder beds can be considered as an equivalent of the middle speckled sandstone must remain doubtful.

Outside the Salt-range there have been detected beds of a similar geological position by Mr. R. D. Oldham in the desert of Rajputana occupying large districts in the vicinity of Jessalmir, Devikote, etc. The beds are here composed of a thick series of red shales and sandstones resting on a glacial boulder bed. The identity of these beds with the speckled sandstone of the Salt-range has been suggested by Mr. Oldham himself. The green sandstones, which generally intervene in the

Salt-range between the boulder beds and the red sandstones of the middle division, seem either to be absent here, or else they are replaced by a thick bed of red shales.

We have seen in the preceding chapter that there are many reasons why the boulder beds of Rajputana, as well as the lower division of the speckled sandstone group of the Salt-range, should be considered as equivalents of the Talchir group of Peninsular India, and more especially that the boulder beds of the Salt-range should be placed on a level with the Talchir boulder beds, whilst the green sandstones above should be brought into connection with the Talchir shales and sandstones.

If we ascend higher in the sequence of rocks in Peninsular India, we come upon a group of rocks, which was for a long time considered as forming part of the Barakar group, but which on a closer examination of the plant-remains, which are found in these beds, has been recognised by Dr. Feistmantel as forming a group by itself. This group has received from this author the name of Karharbari beds. The group seems not to be of very general occurrence in the different coalfields of India, nevertheless it is of great geological importance on account of its fossils being more or less nearly related to those occurring in the upper coal measures of Australia, or as these strata have also been called, the Newcastle beds, with which the Karharbari beds have also most distinctly been correlated by Dr. Feistmantel.

These Newcastle beds follow regularly on the marine series, as it has been defined in the preceding chapter, and the marine series again has been recognised as of the same age as the lower division of the speckled sandstone in the Salt-range. So all this combined makes it highly probable that the middle speckled sandstone should be placed on a level with the Karharbari beds of peninsular India.

To say more on the matter is impossible for the present, as no fossils have been found up to this in the middle speckled sandstone.

D. UPPER SPECKLED SANDSTONE OR LOWER PRODUCTUS-LIMESTONE.

The name "Lower Productus-limestone" had been given by me to this subgroup at the time when the speckled sandstone was yet considered as nearly entirely unfossiliferous, and thus it could not be recognised whether palæontologically there existed any relation to these lower beds, whilst the relation to the higher faunæ was very clear. That geologically the lower productus-limestone was most intimately connected with the speckled sandstone, was known to me already at that time, and I have mentioned already in the introduction to the first volume of the present work that sometimes the "Lavender clays" were intercalated between the fossiliferous beds. Now, after fossils have been found in the lower beds, we know that the connection with them is not purely a geological one,

and thus it appears perhaps more convenient to count the beds here under consideration rather with the speckled sandstone than with the next following higher group.

The composition of the group is very variable according to different localities. On the whole, however, one can say that the further we proceed towards the west the more are the sandstones of which the group is generally composed replaced by limestones; and trans-Indus the division is entirely calcareous and dolomitic, as appears from the section of the Kingriáli cliffs, reproduced *ante*, p. 115.

Other sections of this division have been given already from the Nila-Wan and from Katta. The most important one and at the same time richest in fossils is exposed in the khud below the village of Amb along a watercourse that is visible in one of our landscapes making a little cascade. The section is taken just below this little cascade. See Part 1, present volume. It runs as follows :—

Middle Productus-limestone.
8. Compact siliceous limestones about 200 feet thick.
7. Yellow, dolomitic sandy beds, about 150—200 feet.

Upper speckled sandstone or Lower Productus-limestone.
6. Soft, grey, sandy and crumbling beds, with numerous fossils about 6 feet (Chonetes beds). The species are the following :—
Dielasma truncatum, W.; *Diel. minor*, W.; *Hemiptych. sublævis*, W.; *Hemiptych. himalayensis*, Dav.; *Rhynch. sp.*, *Spirigerella numismalis*, W.,; *Athyr.* cf. *royssii*, Lev.; *Ath. semiconcava*, W.; *Eumetr. grandicosta*; Dar.; *Spir. striatus*, Mart.; *Spir. alatus*, Schl.; *Spir. niger*, W.; *Martiniops. subpentagonalis*, W.; *Orthis pecosii*, Marcou; *Chonetes ambiensis*, W.: *Strophalos nodosa*, W.; *Stroph. tenuispina*, W.; *Stroph. costata*, W.; *Product. spiralis*, W.; *Marginifera ovalis*, W.; *Marginif. transversa*, W.
5. Rusty, coarse sandstones, with large yellow grains of quartz and *Spirifer striatus*, Mart., about 5 feet.
4. Fine-grained white sandstones, with *Fusulinæ* and *Orthis indica*, W. in the upper region, and *Strophalosia plicosa*, W., and *Marginifera ovalis*, W., in the lower region, about 10 feet.
3. Black coaly sandstone, with much pyrites and many fossils; among them *Liebea indica*, W.; *Hemiptychina sublævis*, W.; *Dielasma elongatum*, Schl.; *Athyris acutomarginalis*, W.; *Spir. striatus*, Mart.; *Martinia* cf. *glabra*, Mart.; *Reticularia lineata*, Mart.; *Orthis indica*, W.; *Strept. pelargonatus*, Schl.; *Derbya regularis*, W.; *Strophalosia plicosa*, W.; *Stroph. costata*, W.; *Aulosteges medlicottianus*, W.; *Marginifera ovalis*, W.; *Richthofenia lawrenciana*, Kon.; *Monotrypa mastoidea*, W. and W.; *Orbipora ambiensis*, W. and W.; *Stenopora hemisphærica*, W. and W. The bed is about 6 feet in thickness.

Part of Middle Speckled Sandstone.
2. Lavender clay, 10 feet.
1. Red and white sandstones with intercalations of Lavender clay, 30 feet.

The point that is most striking in this section is the occurrence of such a number of fossils, whilst in all the lower beds fossils have been very rare, if not entirely absent. These fossils appear all of a sudden, and though rocks which cannot be distinguished, for instance, from the white sandstones with fossils mentioned in this section, occur frequently also at different lower levels, yet they have all been found to be devoid of organic remains until one reaches the upper region of the speckled

sandstone, where all of a sudden lots of fossils make their appearance. The character of these fossils is quite a peculiar one and perfectly different from that exhibited by the fauna contained in the lower speckled sandstone.

Another peculiarity of these beds consists in the occurrence of black coaly sandstone, which is not restricted to this section alone, but which is frequently met with at very different localities in this region. It looks very promising with regard to the occurrence of plant-remains, but though I have repeatedly searched diligently for such, I did not succeed in finding anything determinable. I should, however, not be astonished if with time such should be found in the Salt-range.

The chief point of interest in these beds is, however, the marine fauna, which has proved to be composed at different localities of the range of the following species:—

* *Helodopsis abbreviata*, W.
*** *Pleurotomaria punjabica*, W.
*** *Bellerophon* cf. *blanfordianus*, W.
* *Bucania kattaensis*, W.
* *Warthia brevisinuata*, W.
* *Euphemus lenticularis*, W.
* *Antale sp. indet.*
* *Cardinia conjungens*, W.
* *Dolabra arcina*, W.
* *Liebea indica*, W.
* *Aviculopecten crebristriatus*, Kon.
* *Dielasma truncatum*, W.
* „ *minor*, W.
*** „ *elongatum*, Schloth.
*** *Hemiptychina sublævis*, W.
*** „ *sparsiplicata*, W.
*** „ *himalayensis*, Dav.
* *Rhynchonella sp. indet.*
* *Spirigerella numismalis*, W.
*** *Athyris royssii*, Lev.
* „ cf. *royssii*, Lev.
* „ *semiconcava*, W.
* „ *acutomarginalis*, W.
*** *Eumetria grandicosta*, Dav.
*** *Spiriferina cristata*, Schl.
* *Spirifer striatus*, Mart.
*** „ *marcoui*, W.
*** „ *musakhelensis*, Dav.
* „ *alatus*, Schl.
* „ *niger*, W.
* *Martiniopsis subpentagonalis*, W.

*** *Martinia* cf. *glabra*, Mart.
*** *Orthis indica*, W.
* „ *pecosii*, Marcou.
*** *Streptorhynchus pelargonatus*, Schl.
*** *Derbyia regularis*, W.
* *Chonetes ambiensis*, W.
* *Strophalosia plicosa*, W.
* „ *nodosa*, W.
* „ *tenuispina*, W.
* „ *costata*, W.
* *Aulosteges medlicottianus*, W.
*** *Productus lineatus*, W.
*** „ *cora*, Orb.
* „ *semireticulatus*, Mart.
* „ *spiralis*, W.
* „ *bhalensis*, W.
* *Marginifera excavata*, W.
* „ *ovalis*, W.
* „ *transversa*, W.
* „ *echinata*, W.
*** *Richthofenia lawrenciana*, Kon.
* *Polypora vermicularis*, W. and P.
* *Serpulites indicus*, W.
* *Monotrypa mastoidea*, W. and W.
* *Orbipora ambiensis*, W. and W.
* *Stenopora hemisphærica*, W. and W.
* *Fusulina kattaensis*, Schw.
* „ *pailensis*, Schw.
* „ *longissima*, Möll.
* „ *sp. indet.*
* *Margaritina schwageri*, Zittel var.[1]

This fauna, consisting of 62 species and varieties, shows a quite peculiar character of its own. The Brachiopoda by far predominate, composing with 41 species considerably more than one-half of the entire fauna. Among these the *Productidæ* and the *Spiriferidæ* are about equally strongly represented, whilst of the *Terebratulidæ* and *Orthidæ* only comparatively few forms occur.

The general characters that are exhibited by this fauna are decidedly identical with those that are generally exhibited by any European or North American upper carboniferous fauna, though there are but few identical species.

If we take first into consideration what relations there exist between this

[1] In this list ;* signifies species peculiar to this sub-division, *** species extending into higher strata.

fauna and those occurring above and below it in the Salt-range, we find that in reality the relations to the lower faunæ are but very few. In the first place, there is no specific identity to be recorded among the fossils that have been found up to the present in the lower and in the upper speckled sandstone, and only in a single case, in *Bucania warthi* and *Bucania kattaensis*, can a developmental connection between two such forms be recognised. The occurrence of the genus *Serpulites*, which in general only very rarely makes its appearance in beds more recent than lower palæozoic, in the *Conularia* nodules, as well as in the beds here under consideration, is also a feature of affinity which needs to be mentioned. Beyond this, however, nothing more can be recorded; on the contrary, we have seen that the general type of the lower fauna is entirely Australian, whilst that of the upper one is entirely European or North American. The only connecting link that yet exists between the geologically more recent palæozoic faunæ of the Salt-range and those of Australia is the frequent occurrence of the genus *Strophalosia* in both countries, a point to which I shall have to recur later on.

As it is, we must accept the opinion that the lower beds have been formed under influences from the south-west, which must, however, have been very complicated, as just in this direction extended the old Indo-Australian continent; whilst the more recent beds were in their formation decidedly influenced from the north-west, from Europe and North America, and perhaps also from China, as we shall see in the sequel.

Only very few forms were apparently living in the more ancient seas, which were able to preserve their existence through the epochs of change, such as *Bucania* and *Serpulites*, whatever these changes may have been.

With regard to the beds that follow next higher in the series above those here under consideration, the relations of the faunæ are much closer. The following are species that extend from the upper speckled sandstone into the siliceous limestone group :—

Pleurotomaria punjabica, W.
Hemiptychina sublævis, W.
„ *sparsiplicata*, W.
„ *himalayensis*, W.
Athyris royssii, Lév.
Eumetria grandicosta, Dav.
Spiriferina cristata, Schl.
Spirifer marcoui, W.
„ *musakhelensis*, Dav.
Orthis indica, W.
Productus lineatus, W.
„ *cora*, Orb.
Richthofenia lawrenciana, Kon.

Altogether 13 species, which are about one-third of the fauna. Of these

species, five attain their chief development in higher strata, whilst they are found in sporadic specimens only in the beds here under consideration. These are—

Hemiptychina sparsiplicata, W.
„ *himalayensis*, Dav.
Athyris royssii, Lév.
Spiriferina cristata, Schl.
Spirifer musakhelensis, Dav.

Two others, on the contrary, have their chief development in the upper speckled sandstone and occur only in very rare stray specimens in higher strata. These are—

Spirifer marcoui, W.
Orthis indica, W.

Among the fauna contained in the upper speckled sandstone beds, a number of species can be picked out which are identical with shells that have been described previously from other countries and localities where the exact age of the beds in which they occur has been fixed with sufficient certainty. These forms can be divided conveniently into three groups; some of them occur in the carboniferous beds of Europe and most other countries, others are restricted to the coal measures of North America, and a third group is found in the permian beds of Europe.

The first group is composed of the following species:—

Athyris royssii, Lév.
Spirifer striatus, Mart.
Martinia cf. *glabra*, Mart.
Reticularia lineata, Mart.
Productus semireticulatus, Mart.

These five forms have been identified by me with as much certainty as possible. Every one of them occurs in Europe in the Mountain Limestone, though they are not restricted to this geological position but ascend frequently also into higher horizons; so that there is not one among them which would be absolutely characteristic for the mountain limestone formation, and we could just as well count these species among the forms identical with those from the coal measures.

The marine development of the geological horizon on which in Western Europe the coal measures have been deposited is in Europe restricted to the eastern parts, to Russia, and the Ural mountains. According to the most recent data, among which chiefly a most important volume published by Mr. Th. Tchernishew of St. Petersburg must be quoted, which were not yet published at the time of publication of the "Classified list," the species identical with those from the coal measure horizon (upper carboniferous and permo-carboniferous) are the following:—

Athyris royssii, Lév.
Spiriferina cristata, Schl.

Spirifer marcoui, W.
„ *alatus*, Schl.
Reticularia lineata, Mart.
Orthis cf. *indica*, W.
„ *pecosii*, *Marcou*.
Streptorhynchus pelargonatus, Schl.
Productus lineatus, W.
„ *cora*, Orb.
„ *semireticulatus*, Mart.
„ *spiralis*, W.
Richthofenia sinensis, W.

With the exception of the three species, *Ath. royssii*, *Retic. lineata*, and *Prod. semireticulatus*, which have been quoted here again, because they are most characteristic also of the more recent horizon, though they have been cited above already among the forms belonging to the mountain limestone, there are ten species, which are identical with those that have been found outside of India in beds of an upper carboniferous age. To these must be added the genus *Marginifera*, which is very rare in the lower carboniferous, whilst it becomes very frequent in the higher beds. Similarly distributed are the genera *Strophalosia* and *Aulosteges*, with the sole difference that these make their first appearance in the upper carboniferous and attain their chief development afterwards in permian strata.

The last group of forms identical with those of Europe is composed of a few species, which have up to the present been considered as characteristic of the permian formation, but have recently been found also in permo-carboniferous beds. These are—

Dielasma elongatum, Schl.
Athyris royssii, Lév.
Spiriferina cristata, Schloth.
Spirifer alatus, Schl.
Streptorhynchus pelargonatus, Schloth.

Thus we see that there are several different elements of which the fauna of the lower productus-limestone or upper speckled sandstone is made up. By far the largest one containing the greatest number of species is autocthonous, whilst a comparatively small number of forms (14) is identical with those that occur also in other countries. We have seen that among these there are none which would be exclusively characteristic of the mountain limestone, whilst nearly all, with the exception of the five species quoted just above, are either characteristic of the coal measures or the permo-carboniferous strata, or else they are at least no strangers in these deposits. The five permian species quoted above give a yet more recent aspect to this fauna.

Thus, if we wish to find out equivalents of the beds here under consideration in other countries, we must look out for such in the topmost deposits of the carboni-

ferous epoch, or else in the transitional strata that are known to occur at the limit between the latter epoch and the permian formation. Such beds have been made known of late in great numbers, and there is no lack of countries with which to compare the upper speckled sandstone group of the Salt-range. Only Australia, which has furnished so many points of comparison with the lower horizons of the speckled sandstone, must here nearly entirely be excluded; and the only feature which may serve perhaps for a comparison, the occurrence of the genera *Strophalosia* and *Martiniopsis* in both countries, is not worth very much. Nevertheless, homotaxially, there must exist also in Australia beds which are of approximately the same age as the deposits of the Salt-range here under consideration, and these must probably be looked for among the upper beds of the Newcastle series; though all palæontological indications in this respect are absolutely absent at present. Only Queensland can perhaps furnish some points of comparison yet, but this question will be treated of later on at the conclusion of the discussion of the faunæ contained in the middle productus-limestone.

The countries which are geographically least distant are the Himalayas on the one hand and peninsular India on the other. In the Himalayas carboniferous strata have been long known to exist. The strata have been described by Godwin-Austen and Verchere, whilst the fauna has been studied by Davidson and Verneuil. It is very much to be regretted that the results of the latter author's studies have been entrusted to Dr. Verchere for publication, as under his hands they appeared in a form which renders them nearly useless.

The chief localities where the carboniferous fossils have been found are in the Vihi valley near Srinagar in Kashmir. Davidson has described a number of species from this locality, a great part of which is, however, peculiar. Those that are identical with forms occurring also in other carboniferous countries are the following:—

Terebratula sacculus, Mart.
Athyris subtilita, Hall.
Spirifer keithani, Buch.
„ *musakhelensis*, Dav.
Streptorhynchus crenistria.
Productus semireticulatus, Mart.
„ *scabriculus*, Flem.
„ *humboldti*, Orb.
„ *spinulosus*, Sow.

This number of species is just half of the number of forms described by Davidson. Among them are some which also occur in the upper speckled sandstone of the Salt-range, but it is very difficult to tell how far this identity may be extended, as the definition of species as applied in my work is somewhat different from that of Mr. Davidson. The identity is only certain for two forms:—

Athyris subtilita=*Spirigerella derbyi*, W.
Spirifer musakhelensis, Dav.

Of these the first has not been found up to the present in the upper speckled sandstone, but occurs plentifully in somewhat higher beds; whilst the latter extends through the lower, middle and upper productus-limestone.

If we take also into consideration what has been mentioned by Dr. Verchere from the same localities, we find that he also has figured *Spirigerella derbyi*, W., and *Spirif. musakhelensis*, Dav. (Pl. III, f. 1, 1a, Journ. Asiat. Soc., Bengal, 1867). The other plates barely allow of any interpretation except Pl. IV, which really seems to represent a *Strophalosia*.

Finally, Mr. Lydekker has given a note in the Records, Geol. Surv. of India, to the purport that fossils belonging to the genus *Lyttonia* are of very frequent occurrence in the carboniferous deposits of the Kashmir valley.

From all this it appears that the beds of Kashmir containing these fossils must be placed rather high in the carboniferous series, though it is not probable that they should be on the same horizon as the upper speckled sandstone of the Salt-Range, for in the Himalayan beds the percentage of truly carboniferous forms, that is to say, mountain-limestone forms, is by far larger. On the contrary, I should rather be inclined to place these beds on a level more approximating that of the *Conularia* nodules of the Salt-range for several reasons. First there is the affinity amounting near to identity of the *Discinisca warthi*, W., and *kashmeriensis*, Dav., in both beds. Though upon the identity or similarity of a single species a safe correlation cannot be based, yet it can serve as an approximate indication with regard to the relative level of a bed. There are, however, yet other things to be taken into consideration. The *Spirifer vihiana*, Davidson, belongs apparently to the same group of forms as *Spirifer duodecimcostatus*, M'Coy, and appears to differ from that form solely by its greater number of ribs; and the *Spirifer kashmeriensis*, Dav., belongs to the group of *Spirifer vespertilio*, Sow., and differs from that species also solely by its more numerous ribs: so that there are also some slight indications of Australian affinities here. Finally there is *Chonetes lævis*, Dav., to be taken into consideration, which differs from *Chonetes ambiensis* solely by its more transverse outline, and thus can very well be considered as an ancestor of the Salt-range species.

All this combined makes it probable that the Kashmir carboniferous strata should either be placed on a level with the lower speckled sandstone of the Salt-range, or else they should be considered as intermediate in age between the latter beds and the lower productus-limestone or upper speckled sandstone.

The case is different with other beds of an approximately carboniferous age that have been observed by Mr. Hughes on the Milam pass. It is a white crinoidal limestone which has yielded the following fossils:—

Hemiptychina himalayensis, Dav.
Notothyris subvesicularis, Dav.
Athyris royssii, Lév.
Spirifer cf. *glaber*, Martin.

Productus semireticulatus, Mart.
Lyttonia sp.

This assemblage of forms is very much like that occurring in certain beds in the Salt-range, though not exactly like the fauna of the lower productus-limestone. *Productus semireticulatus* is restricted in the Salt-range to the bed last mentioned, so is *Spirifer* cf. *glaber*, whilst the genera *Hemiptychina*, *Notothyris* and *Lyttonia* have their chief development in higher strata. What appears most probable to me is, that these crinoidal limestones of the Milam pass should be placed about on a level with the lower and the lowest beds of the middle productus-limestone. Certainly they are not more ancient, so far as it is possible to judge from their contents as known up to the present.

Both these Himalayan deposits, those of Kashmir and those of the Milam pass, can have their equivalents in Spiti only in the "Kuling shales" of Griesbach. Of the Kashmir beds we know that they are in connection with eruptive rocks, mostly amygdaloids, to which a silurian age is attributed by Mr. Lydekker. This would point to an unconformity such as is stated to exist by Griesbach between the Kuling shales and the lower following strata. It is thus highly probable that we have to look out for the equivalents of the upper speckled sandstone or lower productus-limestone and the whole of the siliceous limestone group of the Salt-range with regard to the Spiti area in the Kuling shales. To say anything more positive in this respect is impossible before Mr. Griesbach's larger work on the subject shall have appeared.

There exists no direct indication, according to which it would be possible to point out among the deposits existing in peninsular India any equivalents of the upper speckled sandstone of the Salt-range. It is only the bathrological position which can lead us in this respect. We have seen that the Talchir beds are the only ones which with tolerable certainty can be correlated with the lower speckled sandstone of the Salt-range, and that on the force of this correlation we had to place the Karharbari beds which follow next higher in the series on a level with the middle speckled sandstone. The upper speckled sandstone is now again higher in its bathrological position, and thus we have probably to look out for equivalents of these beds among the Barakars of peninsular India, but there is no further proof for such a supposition. This is all I can say on the matter.

To the south-east of India there are some localities exhibiting carboniferous strata in the Indian archipelago, in Sumatra, and on the island of Timor.

The beds in Sumatra rest unconformably upon granitic rocks, and are composed of slates with auriferous quartz veins below and of dark limestones above. In both these divisions *Fusulinæ* occur, but in the limestones there exists besides[1] a rich carboniferous molluscan fauna. The species are for a great part peculiar, but those that are identical with European ones, as *Productus pustulosus*, *keyserlingianus*, *longispinus*, *Orthis resupinata* and the genus *Schwagerina*, point to

[1] F. Rœmer: Palæontographica, Vol. XXVII, 1880.

beds which are lower in the geological sequence than the upper speckled sandstone of the Salt-range. Their horizon is probably equal to that of the upper beds of the upper carboniferous limestone of Russia, where also the genus *Schwagerina* is of frequent occurence.

Far more approximated in age to the upper speckled sandstone are probably the carboniferous deposits of Timor. In this fauna already several species, identical with, or allied to, permian species, can be recorded; as *Spirigera royssiana*, Keys., *Spirigera protea*, Abich., *Spiriferina cristata*, Schl., *Camerophoria schlotheimi* (*crumena*). Identical with species from the lower productus-limestone are *Spirifer musakhelensis*, Dav., *Spirigera royssii*, Lév., *Spirifer* cf. *glaber*, Mart., and *Productus semireticulatus*, Mart. *Streptorhynchus pectiniformis*, Dav., which has been quoted by Martin (Sedimente Timors) remains doubtful as the specimen is too bad. I do not, however, think that these beds are absolutely on the same horizon as the Salt-range deposits here under consideration, as the number of species identical with truly lower and middle carboniferous forms, such as *Spirigera globularis*, Phill., *Reticularia lineata*, Mart., var., *conularis*, Grunew., *Orthothetes radialis*, Phill., and *Orthothet. crenistria*, Phill., *Productus semireticulatus*, Martin, and *Prod. punctatus*, Mart., are much more numerous than they are in the upper speckled sandstone. A single species has been recognised as probably identical with an Australian one, *Spirifer tasmaniensis* Morr., but the identification is not above every doubt.[1]

This is the farthest south-easterly point where a fauna, allied to the Salt-range one, has been recorded. Yet farther in this direction the Australian facies of carboniferous deposits begins to appear, and we have seen that the fauna of the lower productus-limestone shows no affinity to Australian faunæ.

Thus we turn back and proceed towards the north-east from India, where we find in China a most interesting carboniferous fauna. The locality is Lo-Ping and the fauna has been described by Kayser in Richthofen's "China." The fossils are contained in thin beds of limestone that are super-imposed on workable coal-seams, with which, however, as yet no plant-remains have been found associated. The whole group of beds has an about horizontal position, whilst more ancient carboniferous strata in the vicinity are folded and dislocated.

The fauna consists of the following species excluding those that cannot well be determined:—

Phillipsia obtusicauda, Kays.
Nautilus orientalis, Kays.
„ *mingshanensis*, Kays.
Orthoceras cf. *cyclophorum*, W.
„ *bicinctum*, Ab.
Macrocheilus cf. *anguliferus*, White.
Aviculopecten m'coyi, Meek & Honjoen.
„ *sp.* (cf. *derajatensis*, W.)

[1] Beyrich. Abhand l. d. Kön., Acad. W., Berlin, 1665.

Myalina trapezoidalis, Kays.
Pinna confutsiana, Kays.
Macrodon carbonarius, Cox.
Schizodus wheeleri, Swallow.
„ *lopingensis*, Kays.
Terebratula hastata, Sow. var.
Lyttonia richthofeni, Kays.
Reticularia lineata, Mart.
„ *elliptica*, Phill.
Martinia glabra, Mart.
Athyris globularis, Phill.
Eumetria compressa, Meek.
Orthis pecosii, Marcou.
Streptorhynchus crenistria, Phill., var. *senilis*, Dav.
Meekella striatocostata, Cox.
Enteletes kayseri, W.
Productus semireticulatus, Mart.
„ *sinuatus*, Kon.
„ *costatus*, Sow.
„ *mexicanus*, Schum.
„ *longispinus* Sow.
„ *plicatilis*, Sow.
„ cf. *compressus*, W.
„ *aculeatus*, Mart.
„ *kiangsiensis*, Kays.
„ *pustulosus*, Phill., var. *palliata*, Kays.
„ *nystianus*, Kon., var. *lopingensis*, Kays.
„ *undatus*, Defr.
„ *carringtonianus*, Davids.
Strophalosia horrescens, Vern.
„ *poyangensis*, Kays.
Richthofenia sinensis, W.
Rhombopora lepidodendroides, Meek.
Fistulipora tuberosa, Kays.
Lophophyllum proliferum, M'Chesney.
Fusulina cylindrica, Fischer, var. *goncilis*, Meek.

I have given a list of this fauna *in extenso* as it is of the utmost importance for the comparison of the beds of the Salt-range with other countries. On a first glance at this list every body will be convinced that it has a by far more thoroughly carboniferous character than any of the faunas described from the Salt-range; and chiefly the list of the species of *Productus* contains numbers of exclusively lower carboniferous forms. At the same time it must not be forgotten that some of the

species are very badly preserved, so that not all the determinations are perhaps above doubt. Nevertheless the number of lower carboniferous species is rather considerable.

A second constituent of this fauna consists of forms identical with those that have been found in the upper barren coal measures of North America, and there are not less than eleven species belonging to this group making about one-fourth of the entire fauna.

A third constituent is made up of forms that are identical with those occurring in the permian of Europe. This forms only a very small fraction of the whole fauna. There is one species, *Strophalosia horrescens*, Vern., directly identical, and another *Strophalosia* is nearly allied to permian forms, the same as nearly all the coal-measure species, which are more or less nearly related to permian species.

Identical with species from the Salt-range are the following :—

Orthoceras cf. *cyclophorum*, W.
Aviculopecten cf. *derajatensis*, W.
Lyttonia richthofeni, Kays.
Reticularia lineata, Mart.
Martinia glabra, Mart.
Orthis pecosii, Marcou.
Enteletes kayseri, W.
Productus semireticulatus, Mart.
„ cf. *compressus*, W.
Richthofenia sinensis, W.

Altogether ten species, about as many as are identical with species from the coal measures of North America. Of these the lower carboniferous forms—

Reticularia lineata,
Martinia glabra,
Productus semireticulatus,

as well as—

Orthis pecosii, Marc.
Richthofenia sinensis, W.

are characteristic for the lower productus-limestone.

Aviculopecten derajatensis, W.
Lyttonia richthofeni, Kays.
Enteletes kayseri, W.
Productus compressus, W.

occur in the middle productus-limestone and—

Orthoceras cyclophorum, W.

is a species of the upper productus limestone.

This is a rather mixed assemblage: however, if we consider that four of the upper and middle productus-limestone species are not quite safely determined, either at Lo-Ping or in the Salt-range, and that on the other hand the lower carboniferous and upper coal-measure forms so enormously predominate, we shall come to the conclusion that the deposits of Lo-Ping cannot well be more recent than the lower productus-limestone, but that there are many reasons to consider them as slightly more ancient. These strata would then be approximately on the level of the middle speckled sandstone, that is to say, on the level of the karharbari beds of peninsular India; and for this reason it is extremely to be regretted that no plant-remains have up to the present been found associated with the coal seams at Lo-Ping.

Prof. Kayser, in working out the results of his description of the Lo-Ping fauna, comes to the conclusion that this fauna has the greatest similarity with the one contained in the upper barren coal measures of North America, and that the Chinese beds containing this fauna must be placed on the same level as those of North America. I perfectly concur with him in this respect, and thus I ought now to enter upon a discussion of the relations that exist between the upper speckled sandstone and the upper coal measures of North America. As however equally close affinities exist between the latter beds and certain divisions of the middle productus-limestone, I shall defer such a discussion until the fauna of the middle productus-limestone will be treated of.

Another country, which all of a sudden has become of fundamental importance for a comparison of the Salt-range deposits with those of Europe, is the southern part of the Ural mountains that has become classical ground through the excellent descriptions of this country by Tschernishew and Karpinsky. When I commenced my work on the Salt-range, one could not have dreamed of finding equivalents of the Salt-range deposits in Europe, as at that time even the distinctness of the carboniferous limestone of Moscow from the mountain-limestone deposits of Belgium was not admitted by Mons. de Koninck. My studies of the Salt-range fossils have slowly brought me to the view that if any equivalents of the Salt-range deposits were existing in Europe, they must be looked for in the Artinsk sandstones, which then could be considered with some probability as the most recent carboniferous deposits, transitional in a degree to the permian, of Europe. This view of mine has been confirmed above all expectation by the works of the learned members of the Russian Geological Survey mentioned above.

The carboniferous system of that country is composed in the following manner according to what I can gather from the Russian literature:—

a. Upper Carboniferous Limestone.

Whitish or light grey limestones, coral limestones, &c., with *Fusulina verneuili, Schwagerina, Spirifer mosquensis, Spirif. striatus, Spiriferina saranæ, Rhynchopora nikitini, Productus villersi, Product. cora, Enteletes, Pronorites, Agathiceras, &c.*

b. Middle Carboniferous Limestone.

Grey limestones with *Productus scabriculus*, *Prod. semireticulatus*, *Prod. costatus*, *Prod. pustulosus*, *Athyris ambigua*, *Ath. subtilita*, *Spirifer trigonalis*, *Dielasma sacculus*, *&c.*

Productus giganteus at some localities.

c. Lower Carboniferous Limestone.

Limestones, sometimes also sandstones and shales with *Productus giganteus*, *Prod. semireticulatus*, *Prod. striatus*, *Athyris expansa*, *Martinia glabra*, *Dielasma hastatum*, *Bellerophon*, *Phillipsia globiceps*, &c.

Some coal seams in the Moscow basin.

Of these beds the lower carboniferous limestone is correlated by Mr. Tschernishew with the limestone of Tournay, of Waulsort and of Visé in Belgium, that is to say, to the entire mountain-limestone.

The middle carboniferous limestone is placed by him on a level with the "terrain houillier non exploité" of Northern France or to the millstone grit of England.

Finally, the upper carboniferous limestone has no marine equivalent in Western Europe, but on account of its geological position it must be considered as on the level of the productive coal-measures of that country.

Above this great limestone series follows a group of beds which are designated as permo-carboniferous by Mr. Tschernishew. This consists below of peppery-grey sandstones, slates, conglomerates, limestones and marls, in which the well-known cephalopoda of Artinsk together with many brachiopoda occur; and above of cavernous limestones and dolomites. The fauna that has been described up to the present from these permo-carboniferous beds consists of the following species:—

Phillipsia grünewaldsi, Möll.
Pronorites præpermicus, Karp., and one other species of the genus.
Parapronorites tenuis, Karp., and two more species.
Medlicottia orbignyana, Vern., and three more species.
Propinacoceras sakmaræ, Karp.
Gastrioceras jossæ, Vern., and four more species.
Paralegoceras tschernischevi, Karp.
Agathiceras uralicum, Karp., and two more species.
Popanoceras lahuseni, Karp., and eleven more species.
Thallassiceras gemmellaroi, Karp.
Paracellites (?) *sp.*
Goniatites sp.
Dielasma elongatum, Schloth.
Athyris pectinifera, Sow.
„ *royssii*, Lev.

Athyris planosulcata, Phill.
Spirifer waageni, Tschern.
„ *alatus*, Schloth.
„ *wynnei*, W.
„ *fasciger*, Keys.
Spiriferina cristata, Schloth.
„ *saranæ*, Vern.
Reticularia lineata, Mart.
Martinia semiplana, W.
Rhynchonella hofmanni, Krotow.
Rhynchopora nikitini, Tschern.
Camerophoria plicata, Kutorga.
Orthis cf. *indica*, W.
Streptorhynchus pelargonatus, Schl.
Chonetes variolaris, Keys.
„ *transitionis*, Krotow.
Productus punctatus, Martin.
„ *cancriniformis*, Tschern.
„ *artiensis*, Tschern.
„ *scabriculus*, Mart.
„ *tenuistriatus*, Vern.
„ *cora*, Orb.
„ *lineatus*, W.
„ *spinulosus*, Sow.
„ *præpermicus*, Tschern.
„ *boliviensis*, Orb.
„ *semireticulatus*, Mart.
„ *spiralis*, W.
Marginifera typica, W.
„ *spitzbergiana*, Toula.
Fusulina verneuilli, Moll.

Among these fossils the great number of cephalopoda and all the other species of local distribution must be neglected in a comparison of the fauna with that of the Salt-range, of however great interest they may otherwise be for fixing the age of these Ural deposits, in which respect we shall yet have occasion to recur to them. The remaining species can be distributed into three sets: first, a group of species can be picked out, which occurs in lower and middle carboniferous beds in Western Europe.

These are the following:—

Athyris royssii, Lév.
„ *planosulcata*, Phill.
Spiriferina cristata, Schl.

Reticularia lineata, Mart.
Productus punctatus, Mart.
„ *scabriculus*, Mart.
„ *spinulosus*, Sow.
„ *semireticulatus*, Mart.

Another group of forms originates in the upper carboniferous limestone of Russia and extends from there up into the permo-carboniferous beds.

These are—

Dielasma elongatum, Schl.
Spirifer fasciger, Keys.
Spiriferina saranæ, Vern.
Rhynchonella hofmanni, Krotow
Rhynchopora nikitini, Tschern.
Camerophoria plicata, Kutorg.
Chonetes variolaris, Keys.
Productus tenuistriatus, Vern.
„ *cora*, Orb.
„ *boliviensis*, Orb.
Fusulina verneuilli, Möll.

Thus we see that just half of the species that have been determined up to the present to occur in the permo-carboniferous beds of the Ural are identical with those from typically carboniferous beds.

A third group can be picked out, that is, composed of species identical with those of the Salt-range. These are—

Dielasma elongatum, Schl.
Athyris pectinifera, Sow.
„ *royssii*, Lév.
Spirifer alatus, Schl.
„ *marcoui*, W.
„ *wynnei*, W.
„ *fasciger*, Keys. (*Spirifer musakhelensis*, according to Mr. Tschernishew.)
Spiriferina cristata, Schl.
Reticularia lineata, Mart.
Martinia semiplana, W.
Orthis cf. *indica*, W.
Streptorhynchus pelargonatus, Schl.
Productus cora, Orb.
„ *lineatus*, W.
„ *semireticulatus*, Mart.
„ *spiralis*, W.
Marginifera typica, W.

Altogether seventeen species, of which thirteen occur in the lower productus-limestone or upper speckled sandstone; whilst of the remaining four species *Marginifera typica* makes its appearance in the beds immediately succeeding, and only *Athyris pectinifera*, *Spirifer wynnei*, and *Martinia semiplana* do not appear below the middle beds of the middle productus-limestone, and of these latter even two have not been determined with absolute certainty. Though this is the case, yet I am not averse to the idea expressed by Mr. Tschernishew that the permo-carboniferous beds of the Ural should be considered identical not only with the lower but also with the middle productus-limestone; only in this wide sense, in which it is applied by Mr. Tschernishew, I should not like to accept this view. We shall see in the sequence that such a correlation can only be accepted for the lowest division of the middle productus-limestone.

A feature that is absent in the Indian beds is the large number of lower carboniferous types (8 species) in the permo-carboniferous beds of the Ural, whilst they are less numerous (only 5 species) in the lower productus-limestone. In the middle productus-limestone their number is by far less considerable, and this is another point which makes me consider the lower productus-limestone chiefly as the equivalent of the Ural beds.

In these latter strata there have been found, besides the marine fauna, also a number of plant-remains, which have been described in detail by Prof. Schmalhausen. Among twenty-six species there are fifteen identical with those from the Russian permian beds, whilst only six are identical with carboniferous forms. The species identical with permian ones are—

Calamites gigas.
„ *decoratus.*
„ *kutorgæ.*
Sphenopteris lobata.
Callipteris conferta.
„ *sinuata.*
„ *permiensis.*
Dolerophyllum goepperti.
Psygmophyllum expansum.
„ *cuneifolium.*
Cordaioxylon permicum.
Dadoxylon biarmicum.
Clathraria densifolia.

Among the indigenous species characteristic of the Artinsk sandstone there are—

Cordaites lancifolius.
Poa-cordaites tenuifolius.
Haidingera cordata.
Zylodendron speciosum.

This flora, even if we do not take heed of the carboniferous forms altogether,

has certainly an entirely palæozoic aspect, and stands in strong contrast to the floræ as they have been found in India. We have seen that the permo-carboniferous beds of the Ural, according to their marine contents, must be placed about on a parallel with the lower productus-limestone of the Salt-range, which in its turn holds a bathrological position about equal to that of the barakars of Peninsular India. For comparison's sake and to let the contrast appear strikingly, I quote here also the flora of these latter beds:—

Schizoneura gondwanensis, Fstm.
Trizygia speciosa, Royle.
Vertebraria indica, Royle.
Cyathea cf. *tchihatchffi*, Schmalh.
Sphenopteris polymorpha, Fstm.
Macrotæniopteris danæoides, Royle.
" *feddeni*, Fstm.
Glossopteris angustifolia, Bgt.
" *tænioides*, Fstm.
" *communis*, Fstm.
" *intermittens*, Fstm.
" *indica*, Schimp.
" *browniana*, Bgt.
" *retifera*, Fstm.
" *damudica*, Fstm.
Pentypterygium balli, Fstm.
Nöggerathiopsis hislopi, Fstm.
Rhipidopsis ginkoides, Schmalh.
Cyclopitys dichotoma, Fstm.

This contrast cannot be more striking, and is the strongest that can be imagined. It is true Dr. Feistmantel declares these beds to be triassic, but would the contrast be less if we compare the flora of the next lower karharbari beds, which Dr. Feistmantel himself declares to be palæozoic? Thus I think it is evident that at the time of transition between the carboniferous and permian periods, floral provinces, depending on climatic and geographical influences, existed in which the individual floræ were of entirely different composition. Even with regard to the marine organisms something similar has been stated by me in the Australian region.

Returning to the main subject, the following question arises: If the permo-carboniferous beds of the Ural are approximately identical with the lower productus-limestone, what age is to be attributed, according to the European standard, to the beds that follow next lower in the section, *i.e.* the middle and the lower speckled sandstone? Are they to be placed on a level with the upper carboniferous limestone of Russia, that is to say, with the productive coal measures of Western Europe? The decision of this question is not so simple as it appears on a first glance. Though the marine fauna of the permo-carboniferous strata is composed, with regard to the brachiopoda, half of forms that are identical with such

as occur also in the lower beds (the upper carboniferous limestone), yet there occur also in the former all those cephalopoda which exhibit a perfectly strange type with but little affinities to more ancient forms. Thus, if we consider the whole fauna, not the brachiopoda alone, we find the affinity with the lower beds much less close than otherwise. Also the flora exhibits a closer affinity to that of the next higher than to that of the lower beds. Next comes the character of the rock. This is described by Mr. Tscherishew as very variable, often containing conglomerates, a character which is suggestive of a littoral deposit, a suggestion that is yet confirmed by the circumstance that the Artinsk sandstones are often found to rest in a transgressive manner, discordantly on disturbed devonian rocks, though generally they follow regularly above the upper carboniferous limestone. Thus evidently some change of level has taken place, and the possibility is not excluded that some break in the succession has to be accepted; so that some small amount of beds may be absent between the upper carboniferous limestones and the permo-carboniferous strata.

Thus the Salt-range beds, of which we wish to ascertain the age, could just fit into this break, and they could yet be more recent than the productive coal-measures of Western Europe. This supposition is confirmed by other facts. In China we have seen that beds probably more ancient than the lower pruductus-limestone are represented by the deposits of Lo-Ping. The coal-basin in which this locality is situated has been considered by Baron Richthofen as of permian age because it is more recent than any of the other coal-basins of China in which upper carboniferous plants have been found.

The same is the case in Southern Africa. We had already several times occasion to allude to the affinity that exists between the Gondwana-system of peninsular India and the so-called Karoo-formation of Southern Africa, and most recently Dr. Feistmantel has published in the "Sitzungsberichte der Kón. bóhm. Gesellsch. d. Wissenschaften for 1888," a very able and comprehensive compilation of all the facts that we know up to the present with regard to the geology of Southern Africa and their bearing upon the geology of peninsular India. From this it appears most clearly that there, below the Dwyka or Ekka boulder beds, a series of sandstones is exposed, which have furnished a number of plant-remains identical with those of the productive coal measures of Western Europe. As now those boulder beds are generally accepted as an equivalent of the talchir boulder beds of peninsular India, and these again are to be considered as identical with the boulder beds of the lower speckled sandstone of the Salt-range, it is evident that the productive coal measures of Western Europe are on a lower level than all the speckled sandstone group.

From all this it becomes probable that there is a break in the sequence of beds in the Ural, and that a number of beds are absent there, which fit in between the permo-carboniferous beds, or especially between the Artinsk sandstones and the upper carboniferous limestone of Russia.

But is then my former indication that the lower productus-limestone, as well as the boulder beds, of the Salt-range had to be considered as equivalents of the coal measures, to be designated as erroneous and requiring correction? It is partly so

and partly not. At the time when I wrote the preface to Vol. I and, later on, my paper on the carboniferous glacial period, it was not possible to make a proper distinction between the coal measures and the permo-carboniferous beds, as in America the latter were also generally called coal measures; and so I was perfectly justified in including everything up to the limits of the "Rothliegende" in the coal measures. Now, however, the case is different. Through the excellent investigation of Mr. Tschernishew in the Ural we have learnt to draw a distinctive line between the carboniferous beds properly speaking and a higher following series of rocks, the age of which with regard to the standard sequence of formations has yet to be settled.

The opinion generally prevails that where the carboniferous properly speaking terminates, the permian has to commence, and I have on the whole no objection to such a view; but one must not forget that, simple as this was, so long as our knowledge was limited, it appears difficult now, after our knowledge has considerably increased. The beds here under consideration cannot find any place in the system if we stick to the limits of formations as they have formerly been accepted: if we terminate the carboniferous with the upper limits of the productive coal measures, as has been done generally in Europe, and begin the permian with the lowest beds of the "Rothliegende," the entire speckled sandstone group and also some beds above are without a place as they just fill up the break existing in Western Europe generally between the carboniferous and the permian.

This has been perfectly recognised by Tschernishew and Karpinsky; and thus they recur to the old name of permo-carboniferous, a name which has been applied already years since promiscuously to all possible and impossible strata, as no fixed sense could be brought up to the present into connection with it. Tschernishew and Karpinsky now propose to restrict it to certain beds, of which those exposed in the Southern Ural ought to serve as prototype. I have, on the whole, no objection against such a proceeding. It is only to be regretted that apparently in the Ural the succession of strata is not quite complete.

Another way of treating the matter has been pointed out by Mr. Gümbel in his Hand-Book of Geology, a most important publication in every respect. He proposes to consider the Permian not as a Dyas, as has been done by Geinitz and Marcou, but to divide it into three sub-divisions. There are certain beds existing in Europe, which have mostly furnished remains of Vertebrates, chiefly fishes and amphibia, and plants, and which hold a position either very high in the carboniferous or very low in the permian system. These are chiefly the shales of Lebach with *Archegosaurus*, the "Hangend Flötze" and perhaps the gas coals of the Bohemian carboniferous basins, &c. The plant-remains in these beds are for the greater part carboniferous species, but some are intermixed with them which belong to permian forms, as they generally are found in Europe. These beds Gümbel proposes now to unite into a lower division of the permian system, whilst the "Rothliegende" would then form the middle and the magnesian limestone, the upper division of the same system. Already Karpinsky in his Monograph of the Artinsk Ammonea has pointed to the probability that the first-named beds had to be considered, as on the same level as the

permo-carboniferous strata of the Ural, and that in such a way these latter, if we accept Mr. Gümbel's views, had to be placed in the permian.

The permian, however, which then results, is not identical with what generally has been called Permian.

I shall not go more into detail with regard to this question now, reserving such a discussion for the concluding chapter of the palæozoic era.

2. SILICEOUS LIMESTONE GROUP.

This group is the most conspicuous one among all the upper palæozoic series of the Salt-range. However, notwithstanding this circumstance, it is very difficult to get a clear section of all the beds, as the lowest beds are mostly concealed by a talus of débris from the steep limestone cliffs above, or else the cliffs themselves are so precipitous that the upper beds are very difficult of access; only the softer higher beds are again more easily accessible. These difficulties are the cause of my not being able to give a general section of all the groups at once, and that I am only in a position to give single sections of the different parts.

According to the different character of the rock, the group can be easily divided into two sub-divisions—the lower one consisting of strong cliff-limestones, the upper one of softer, mostly yellow sandy dolomitic beds.

The strong limestones are a very striking feature in all the landscapes in the Salt-range, where they are developed in somewhat greater force. The easternmost place where I have observed them is near Katta, where they are about 50 feet thick. The sandy dolomitic beds make their appearance only still farther to the west.

The surface sculpture of the country is mostly determined by the siliceous limestone group, and, as an example of this, I may be allowed to reproduce here a little section that I have taken down on the road between Virgal and Uchali.

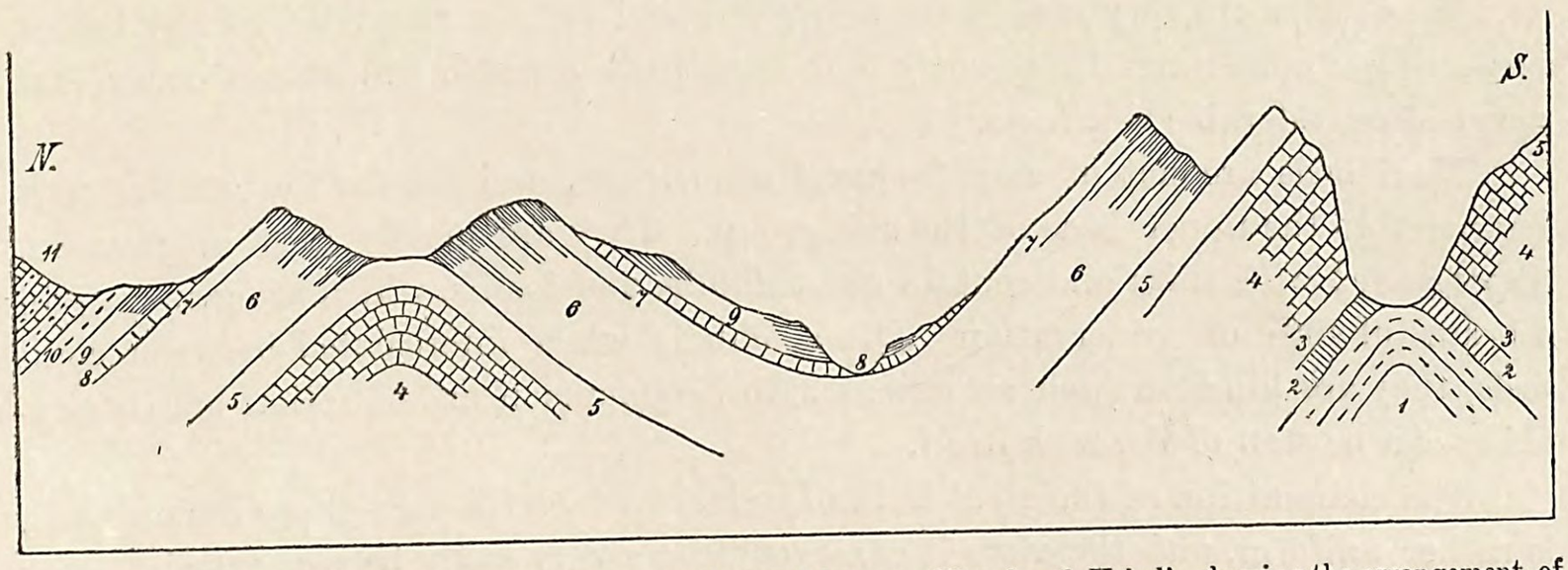


Fig. 7. Section through part of the Salt-range on the road between Virgal and Uchali, showing the arrangement of the single sub-divisions of the siliceous limestone group. 1, Lavender clay (Middle Speckled sandstone); 2 Upper Speckled sandstone or Lower Productus-limestone; 3, Lower division of the Middle Productus-limestone; 4, Middle division of the same; 5, Upper division of the same; 6, Upper Productus-limestone, lower and middle divisions; 7, Top beds of the Upper Productus-limestone; 8, Ceratite limestone; 9, Ceratite marl; 10, Ceratite sandstone; 11, Variegated group.

This section shows at the same time the general composition of the group and its division into two parts.

I proceed to discuss these two sub-divisions separately.

a. Middle Productus-limestone.

The rocks of which this division is composed are generally light-coloured, white, or greyish or yellowish limestones, impregnated with silica, which is, however, of very unequal distribution. Sometimes it is gathered in great lumps, which show a very uneven surface, and consist in the interior of true flint. Generally, however, the silica is not present in such quantity, but there are few cases where the shells of the fossils are not converted into a siliceous mass, either entirely or at least the outer coating. If this latter takes place the silica exhibits often a dark brown colour, so that the half-weathered-out fossils can be distinguished from a distance on the light-coloured rock surface. In such a case, however, they are extremely difficult to extract. Beautiful bodies of *Eocidaris forbesi*, Kon., for instance, preserved in such a manner could not be brought away. Sometimes the limestones are filled with countless corals forming true coral reefs.

Another variety of rock that occurs very frequently, but which is generally not of great thickness, is a dark brown, somewhat sandy, often crystalline dolomite. It is mostly devoid of organic remains, and only when it occurs in a very low geological position at the base of the sub-group, I have sometimes found *Fusulinæ* in it which could, however, not be extracted. This rock occurs at very different geological positions, but is most frequently met with either at the base of the sub-group as just stated, or else at the very top of it, just at the limit towards the upper productus-limestone. Sometimes, however, it occurs also at other levels, and this quite indiscriminately, so that no certain geological horizon can be fixed by its presence.

Sandstones are very rare in the sub-group and mostly restricted to the lowest beds, where sometimes black coaly and sometimes greenish sandstones occur, but never of considerable thickness.

Marl beds are not of very frequent occurrence, and are for the greater part restricted to the upper beds of the sub-group. They are mostly grey or greenish, impregnated with silica and contain great numbers of fossils, which are generally in a beautiful state of preservation. Often, chiefly when intercalated between coral beds, they are filled to such an extent with fragments of crinoids, that hardly anything can be seen of the rock itself.

The composition of the great bulk of beds, of which this sub-group is composed, is rather uniform, and therefore it can everywhere very easily be recognised. Only with regard to the lower and upper beds some variation takes place. In this respect it seems necessary to quote some examples.

One of the sections, in which the lower beds of the sub-group are most characteristically developed and very rich in fossils, is that of Katta. I had occasion

already to describe a part of this section on p. 116 of the present volume in discussing the lower productus-limestone or upper speckled sandstone beds.

The last bed quoted on that occasion was designated No. 10 and consisted of hard grey sandstones with *Fusulinæ*. Above these follow (11) hard rusty dolomites 50 feet in thickness with rare fossils, among which species of *Bellerophon* and other Gasteropods were recognised, but could not be detached. They are covered (12) by a series of thinly bedded limestones with intercalations of marls, barely more than 5 feet in thickness, but with countless fossils; among these have been determined *Pleurotomaria kattaensis*, W.; *Dielasma elongatum*, Schl.; *Diel. nummulus*, W.; *Hemiptychina sparsiplicata*, W.; *Notothyris simplex*, W.; *Terebratuloidea minor*, W.; *Ter. ornata*, W.; *Athyris globulina*, W.; *Eumetria indica*, W.; *Uncinella indica*, W.; *Spiriferina cristata*, Schl.; *Spirifer musakhelensis*, Dav.; *Streptorhynchus pelargonatus*, Schl.; *Strept. lenticularis*, W.; *Chonetella nasuta*, W.; *Richthofenia lawrenciana*, Kon.; *Cyathocrinus kattaensis*, W.

Yet higher in the series follow (13) greyish green sandy marls, also about 5 feet thick, with a few rare fossils: *Bellerophon* cf. *blanfordianus*, W.; *Warthia lata*, W.; *Orthis indica*, W.; *Leptæna indica*, W.

The section is finally closed by (14) light grey siliceous limestone, of a thickness of 50 feet, with many irregular flint-concretions and many fossils converted into brown silica, and among these chiefly *Eocidaris forbesi*, Kon., which however only could be detached in fragments from the rock.

The thickness of these siliceous limestones is comparatively very small, and it is evident that the entire thickness of limestones generally composing the middle region of the Middle Productus-limestone is not represented here. Similarly the upper, marly, division is here also absent.

Another section, which can well serve to complete the one from Katta, has been observed by me near Khura, a little village which is situated on the road between Sothi and Katwahi. If one comes from Sothi and has just crossed the little pass, consisting of an anticlinal of nummulitic limestone, a high precipitous mountain is very conspicuous to the right of the road exposing a high sheer precipice directly towards the observer. This mountain consists of the limestones, composing the middle productus-limestone, which form a flat anticlinal, one wing of which descends towards the south-west into a little valley where a section can be seen. On reaching the entrance of this valley, I found that the precipice was not at all formed of the true productus-limestone, but by a huge mass of fault-breccia made up of limestone fragments. It formed a vertical bed of about 20 feet thickness, covering the entire front of the precipice. Only after having crossed this breccia, I was able to commence measuring the section, which is composed in the following manner, from above downwards, though I commenced measuring from below—

Upper Productus-limestone (part of).	4	Yellowish sandy dolomitic beds of little hardness, partly marly and siliceous with many fossils: *Bellerophon jonesianus*, Kon.; *Derbyia hemisphærica*, W.; *Streptorhynchus pectiniformis*, Dav.; *Marginifera typica*, W.; *Arcestes* (?) *priscus*, W.

Middle Productus-limestone.

Upper division.

3 Marly beds of a grey colour intercalated with marly limestone with the following fossils: *Nautilus connectens*, W.; *Gyroceras medlicottianum*, W.; *Orthoceras punjabiense*, W.; *Euomphalus parvus*, W.; *Pleurotomaria punjabica*, W.; *Loripes proavius*, W.; *Nucula trivialis*, Eichw.; *Dielasmina plicata*, W.; *Hemiptychina himalayensis*, Dav.; *Notothyris djulfensis*, Ab.; *Nototh. lenticularis*, W.; *Lyttonia tenuis*, W.; *Camerophoria purdoni*, Dav.; *Spirigerella derbyi*, W.; *Athyris royssii*, Lev.; *Chonetella nasuta*, W.; *Productus lineatus*, W.; *Prod. indicus*, W. The whole about 10—15 feet.

Middle division.

2 Grey hard marly limestones, with little silica and few softer marly intercalations, 50 feet in thickness: *Euomphalus parvus*, W.; *Macrodon geminum*, W.; *Hemiptychina sparsiplicata*, W.; *Lyttonia* cf. *richthofeni*, Kays.; *Productus lineatus*, W.; *Prod. indicus*, W. The fossils can be detached only with difficulty from the hard rock.

1 White saccharoid limestone in thick beds: many fragments of crinoids and corals; besides this *Productus lineatus*, W. About 50 feet exposed.

These two sections may suffice to give a general idea of the mode in which the middle productus-limestone is generally composed. Three sub-divisions can always be distinguished within this sub-group, which to a certain extent are also characterised by a special fauna. It will, therefore, be practical to consider each of these sub-divisions separately and in discussing the faunæ in detail, where necessary, to compare them with those of foreign deposits.

a. Lower Division of the Middle Productus-Limestone.

This lower division has a very different aspect at different localities, and it is not very sharply defined from the lower productus-limestone. I have generally drawn the boundary line between the lower and middle productus-limestones where the sandstones begin to disappear and limestones become the leading rocks. This boundary line is, however, not always quite clear, chiefly when those rusty dolomites, which I have adduced on the foregoing pages as a characteristic rock of the middle productus-limestone, make their appearance. Then apparently the entire lower division of the middle productus-limestone and even part of or the entire lower productus-limestone seem to be represented by such dolomites which are nearly always devoid of fossils.

If the beds are normally developed, they are mostly made up of light-coloured yellowish or whitish limestones intercalated with a few marly and sandy beds. At a few places, however, as at Narsing Pahar, etc., the beds are black and coaly.

The fauna is not very rich and there have been described from these beds in Vol. I the following species:—

* *Nautilus ophioneus*, W.
* *Pleurotomaria kattaensis*, W.
** *Bellerophon* cf. *blanfordianus*, W.
* *Warthia lata*, W.

* *Dielasma guttula*, W.
* „ *elongatum*, Schl.
* „ *nummulus*, W.
* „ *itaitubense*, Derby.
** *Hemiptychina sublævis*, W.
** *** „ *sparsiplicata*, W.
** *** „ *himalayensis*, Dav.
* *Notothyris simplex*, W.
*** *Terebratuloidea minor*, W.
* „ *ornata*, W.
*** *Athyris subexpansa*, W.
*** „ *globularis*, W.
* *Eumetria indica*, W.
* *Uncinella indica*, W,
** *** *Spiriferina cristata*, Schl.
** *Spirifer marcoui*, W.
** *** „ *musakhelensis*, Dav.
* *Enteletes ferrugineus*, W.
*** *Orthis indica*, W.
* „ *incisiva*, W.
** *Streptorhynchus pelargonatus*, Schl.
* „ *lenticularis*, W.
* „ *capuloides*, W.
* „ *deltoideus*, W.
* *Leptæna indica*, W.
*** *Chonetes morahensis*, W.
* „ *strophomenoides*, W.
* „ *compressa*, W.
* *Strophalosia horrescens*, Vern.
*** *Chonetella nasuta*, W.
*** *Productus gratiosus*, W.
*** *Marginifera typica*, W.
** *** *Richthofenia lawrenciana*, Kon.
* *Cyathocrinus indicus*, W.
* „ *kattaensis*, W.
* *Poteriocrinus* (?) *sp. ind.*
*** *Dybowskiella grandis*, W. & W.
*** *Amblysiphonella vesiculosa*, Kon.[1]

The most characteristic features of this fauna consist in the frequency of the genera *Streptorhynchus* and *Dielasma*, each of which is represented by four species, and in the occurrence of two species of *Cyathocrinus*, etc.

[1]As in other lists, * signifies also here species peculiar to the bed, ** species extending from below, *** species extending into higher beds, ** *** species coming from below and extending into higher beds.

The species, entirely restricted to this bed, are not very numerous, not more than 21 species, which is just half of the entire number of forms that have been found up to the present.

By the other half of its species this fauna shows manifold relations to those below and above. According to the number of species which are common to the beds here under consideration and the others, the relation seems to be more close to the ones above than to those below.

With the beds below, that is to say, with the lower productus-limestone, the sub-division here under consideration has the following species in common:—

Bellerophon cf. *blanfordianus*, W.
Dielasma elongatum, Schl.
Hemiptychina sublævis, W.
„ *sparsiplicata*, W.
„ *himalayensis*, W.
Spiriferina cristata, Schl.
Spirifer marcoui, W.
„ *musakhelensis*, Dav.
Orthis indica, W.
Streptorhynchus pelargonatus, Schl.
Richthofenia lawrenciana, Kon.

With the beds above, that is to say, with the middle division of the middle productus-limestone, the following species are in common:—

Hemiptychina sparsiplicata, W.
„ *himalayensis*, Dav.
Terebratuloidea minor, W.
Athyris subexpansa, W.
„ *globularis*, W.
Spiriferina cristata, Schl.
Spirifer musakhelensis, Dav.
Orthis indica, W.
Chonetes morahensis, W.
Chonetella nasuta, W.
Productus gratiosus, W.
Marginifera typica, W.
Richthofenia lawrenciana, Kon.
Dybowskiella grandis, W. & W.
Amblysiphonella vesiculosa, Kon.

Thus we see that there are in the first category 11, and in the second 15 species. These numbers are, however, very little reliable, as already in the lower productus-limestone we had to record a number of species, which appear again in higher beds of the siliceous limestone series, whilst they have not been found up to the

present in the strata here under consideration, a circumstance which proves how imperfectly the fauna of these latter is as yet known to us.

On the whole, it is not to be wondered at that the relations to the superimposed strata appeared to be more close, as both the lower and the middle divisions are composed of limestones, which make similar conditions for deposition probable, whilst the lower productus-limestone, mostly composed of sandstones, has evidently been formed under very different conditions.

On the whole, the number of peculiar species in these beds seems for the present sufficient to warrant their separation on palæontological grounds.

The relations of this fauna to that of non-Indian deposits are not very strongly pronounced. The first thing that strikes the observer is that there are so very few forms among the whole lot, which are identical with species, which have been considered up to quite recent times as truly carboniferous, though they are not such in reality. The species that can be quoted in this respect are—

Dielasma itaitubense, Derb.
Spirifer marcoui, W.

both from the upper coal-measure deposits of America, the first from those of Brazil, the second from Western North America.

Much more close are the relations that exist to permian deposits. The following species are identical :—

Dielasma elongatum, Schl.
Spiriferina cristata, Schl.
Streptorhynchus pelargonatus, Schl.
Strophalosia horrescens, W.

Of these the last-named species is of great importance, as it has never yet been quoted from beds lower in the series than true permian.

The relations of the fauna here under consideration to that of the permo-carboniferous beds of the Ural, as described by Tschernishew, have been hinted at already on one of the foregoing pages. The occurrence of *Marginifera typica* with *Streptorhynchus pelargonatus* makes it highly probable that also these beds, the lower division of the middle productus-limestone, have their representatives in the permo-carboniferous deposits of the Ural.

b. Middle Division of the Middle Productus-limestone.

As has been stated already above, in describing the middle productus-limestone in general, this sub-division consists entirely of compact limestones of rather variable thickness and rather different description at different places. The compactness of the material causes this sub-division to be the most conspicuous member of the entire productus-limestone formation, and where it is well exposed sheer precipices are formed by it, as its thickness is generally very considerable.

At most places the sub-division is composed of light grey limestones in thick beds with rare thin marly intercalations here and there. Silica is always present, but in varying quantities. Sometimes large flint-concretions are formed, but this is rather exceptional.

The organic remains are extremely numerous in these beds, but the rock is very little adapted for collecting them, and it is generally possible to get specimens of a satisfactory preservation, only when one meets with a thicker marl bed, where the fossils can be detached with ease. It is therefore most probable that, though already a considerable number of species has been detected in these beds, the greatest number of new discoveries of fossils, hitherto not known, will be made in the future in this sub-division.

A very remarkable character of the fauna contained in this sub-division is the frequent occurrence of corals often in enormous colonies, of which only small portions can be detached. Mostly they are found single, that is to say, each colony, large as it may be, by itself. At some places, however, they are heaped together in great masses, as at Virgal, etc. Then also the character of the rock changes to a certain extent, as it is transformed into a white more or less saccharoid limestone, which also often exhibits reddish tints and is intercalated with red crinoid marls. The bedding is then also often more or less indistinct, and the whole forms a coral reef of imposing dimensions. In these cases silica is but very sparingly disseminated, and specimens which allow of the preparation of microscopic slices must always be selected from such localities.

The upper and lower limit of the sub-division is rather arbitrary. I have generally drawn the lower limit where sandy beds have altogether disappeared, and marl beds became of rare occurrence. As the upper limit, I have considered that region where thick grey siliceous marls, with numerous but thin limestone bands, made their appearance.

The fossils that have been collected up to the present in this sub-division are the following:—

* *Pœcilodus paradoxus*, W.
* *Psephodus depressus*, W.
* *Psammodus sp. indet.*
* *Nautilus peregrinus*, W.
*** *Euomphalus parvus*, W.
*** *Macrocheilus avellanoides*, Kon.
*** *Bellerophon jonesianus*, Kon.
* „ *squamatus*, W.
*** *Macrodon geminum*, W.
*** *Pseudomonotis garforthensis*, King.
* „ *gigantea*, W.
*** *Oxytoma atavum*, W.
* *Aviculopecten derajatensis*, W.
* „ *morahensis*, W.

* *Pecten wynnei*, W.
? „ *flemingianus*, Kon.
*** *Dielasma biplex*, W.
*** „ *problematicum*, Dav.
***** *Hemiptychina sparsiplicata*, W.
***** „ *himalayensis*, Dav.
*** „ *inflata*, W.
*** *Notothyris warthi*, W.
*** „ *minuta*, W.
*** „ *multiplicata*, W.
*** *Lyttonia nobilis*, W.
*** „ *tenuis*, W.
* „ cf. *richthofeni*, Kays.
*** *Oldhamina decipiens*, Kon.
*** *Terebratuloidea davidsoni*, W.
** „ *minor*, W.
* *Rhynchonella morahensis*, W.
*** *Camerophoria purdoni*, Dav.
* „ *humbletonensis*, Howse.
* „ *pinguis*, W.
*** „ *superstes*, Vern.
*** *Spirigerella derbyi*, W.
*** „ *minuta*, W.
*** „ *grandis*, W.
*** „ *media*, W.
***** *Athyris royssii*, Lév.
***** „ *sub-expansa*, W.
*** „ *capillata*, W.
** „ *globularis*, W.
*** „ cf. *pectiniformis*, Sow.
***** *Eumetria grandicosta*, Dav.
***** *Spiriferina cristata*, Schloth.
* „ *nasuta*, W.
***** *Spirifer musakheylensis*, Dav.
* „ *wynnei*, W.
* „ *oldhamianus*, W.
*** *Martinia elongata*, W.
*** „ *warthi*, W.
* „ *semiplana*, W.
*** *Reticularia indica*, W.
* „ *elegantula*, W.
* *Enteletes kayseri*, W.
* „ *sublævis*, W.

* *Enteletes pentameroides*, W,
*** *Orthis derbyi*, W.
* „ *marmorea*, W.
***** „ *indica*, W.
* „ *janiceps*, W.
* „ *corallina*, W.
* *Streptorhynchus operculatus*, W.
*** „ *pectiniformis*, W.
** *Derbyia regularis*, W.
*** „ *grandis*, W.
* „ *vercherei*, W.
***** *Chonetes morahensis*, W.
* „ *squama*, W.
* „ *semiovalis*, W.
* „ *dichotoma*, W.
*** „ *squamulifera*, W.
* „ *deplanata*, W.
*** *Strophalosia rarispina*, W.
***** *Chonetella nasuta*, W.
***** *Productus lineatus*, W.
***** „ *cora*, Orb.
*** „ *sub-costatus*, W.
*** „ *indicus*, W.
* „ *vishnu*, W.
***** „ *gratiosus*, W.
*** „ *asperulus*, W.
* „ *humboldti*, Orb.
*** „ *abichi*, W.
*** „ *tumidus*, W.
*** „ *compressus*, W.
***** *Marginifera typica*, W.
***** *Richthofenia lawrenciana*, Kon.
*** *Cardinocrania indica*, W.
*** *Fenestella perelegans*, Meek.
*** *Polypora koninckiana*, W. & P.
*** „ *megastoma*, Kon.
* „ *gigantea*, W. & P.
*** „ *ornata*, W. & T.
* „ *sykesi*, Kon.
* „ *transiens*, W. & T.
* *Phyllopora haimeana*, Kon.
*** *Synocladia virgulacea*, Phill.
* *Goniocladia indica*, W. & T.

* *Thamniscus dubius*, Schl.
*** „ *serialis*, W. & T.
* *Acanthocladia anceps*, Schl.
* *Rhombopora obliqua*, W.
*** *Spirorbis helix*, King.
* *Eocidaris forbesiana*, Kon.
*** *Cyathocrinus goliathus*, W.
* „ *virgalensis*, W.
* *Poteriocrinus sp. indet.*
** „ *sp. indet.*
* *Philocrinus cometa*, Kon.
* *Avæopora tuberosa*, W. & W.
* *Michellinia indica*, W. & W.
* „ cf. *glomerata*, M'Coy.
*** *Geinitzella columnaris*, Schl.
*** *Stenopora ovata*, Lonsd.
* *Lonsdaleia salimaria*, W. & W.
* „ *wynnei*, W. & W.
*** „ *indica*, W. & W.
* „ *virgalensis*, W. & W.
* *Amplexus cristatus*, W. & W.
*** *Hexagonella ramosa*, W. & W.
* „ *tortuosa*, W. & W.
* „ *lævigata*, W. & W.
***** *Dybowskiella grandis*, W. & W.
*** *Fistulipora parasitica*, W. & W.
* *Carterina pyramidata*, W. & W.
* *Disjectopora milleporæformis*, W. & W.
* *Irregulatopora undulata*, W. & W.
* *Circopora faveolata*, W. & W.
* „ *tubulosa*, W. & W.
***** *Amblysiphonella vesiculosa*, W. & W.
* „ *radicifera*, W. & W.
* „ *multilamellosa*, W. & W.
* „ *socialis*, W. & W.
* *Steinmannia gemina*, W. & W.[1]

Altogether 136 species, of which, however, not more than 70 are peculiar to the present sub-division.

The relations of this fauna to those below and above it are very characteristic,

[1] As in other lists, * signifies also here species peculiar to the bed, ** species coming from below, *** species extending above, ***** species coming from below and extending above.

and give occasion for several conclusions. There are 17 species of this fauna identical with those that occur also in lower strata, whilst not less than 64 can be identified with forms occurring in beds situated higher up in their bathrological position. Of these are again 6 ubiquitous in the Salt-range, extending from the lower through the middle into the upper productus-limestone; so that both the numbers given above can be reduced by 6.

From this it appears very clearly that the relations of the faunæ of the middle division of the middle productus-limestone are much more intimate with the faunæ following above than those preceding it. This contrast becomes chiefly striking if we consider that both the lower as well as the middle divisions are composed of limestones, so that the difference cannot be caused by a change in the "facies" of the strata between the two divisions.

Thus it is apparently a chief boundary line that extends between the middle and the lower divisions of the middle productus-limestone, and I am inclined to draw here the limit between the permian and the permo-carboniferous formations.

This view is yet further confirmed by the relations that are exhibited between the faunæ here under consideration and those of foreign countries.

If we pass in review the list of species just given, we find only very few forms among them which are identical with truly lower carboniferous species. In this respect can only be quoted—

Athyris royssii, Lev.
Michelinia cf. *glomerata*, M'Coy.

Much more numerous are those forms which can be identified with such species as have been found elsewhere in upper carboniferous strata, that is to say, in the upper coal-measures or the upper carboniferous limestone. Such forms are the following:—

Camerophoria superstes, Vern.
Spirigerella derbyi, W.
Athyris royssii, Lév.
Spirifer musakhelensis, Dav. (= *Spir. fasciger*, Keys)
Productus lineatus, W.
„ *cora*, Orb.
„ *humboldti*, Orb.
Fenestella perelegans, Meek.
Stenopora ovata, Lonsd.

The greatest number of species within this fauna of the middle division of the middle productus-limestone, which have proved to be identical with such already formerly described from other countries, are permian, and these are the following:—

Macrocheilus avellanoides, Kon.
Pseudomonotis garforthensis, King.

Camerophoria humbletonensis, Howse.
„ *superstes*, Vern.
Athyris royssii, Lév.
Spiriferina cristata, Schloth.
Productus humboldti, Orb.
„ *abichi*, W.
„ *tumidus*, W. (?= *Prod. cancrini* (Vern.) Tschernischew.)
Fenestella perelegans, Meek.
Synocladia virgalacea, Phill.
Thamniscus dubius, Schl.
Acanthocladia anceps, Schl.
Spirorbis helix, King.
Geinitzella columnaris, Schl.

These foreign species, which have been identified by me with those occurring in the Salt-range, are mostly of a very wide and very varying geographical distribution, and it appears now necessary to compare those deposits in which similar forms in different countries occur more in detail with the Salt-range strata.

If we again start from the geologically oldest species, it is immediately apparent that there need not be instituted any comparison with any lower carboniferous strata; as of the two species which have been found to be identical, the one, *Athyris royssii*, extends from the lower through the upper carboniferous into the permian, and the second, *Michelinia* cf. *glomerata*, M'Coy, could not be determined with sufficient accuracy. Thus any affinity of this fauna with the lower carboniferous is absolutely problematic.

Of the species identical with those of the upper carboniferous, two different sets can be distinguished, one with eastern and the other with western affinities. Both are constituted of about an equal number of species, and the first group points to a relation of this fauna to the fauna of the upper carboniferous limestone and the permo-carboniferous deposits of Russia, and the latter, among which chiefly—

Spirigerella derbyi, W., and
Fenestella perelegans, Meek.,

are of importance, points to a certain affinity with the strata of the upper coal measures of North America.

As, however, in both cases the number of identical species is rather limited, it would not be prudent to infer from these relations the identity of the middle division of the middle productus-limestone with the mentioned deposits of Russia and North America, chiefly as there is yet another set of species identical with those of other countries pointing to other affinities.

Nevertheless it cannot be denied that such a celebrated authority in these questions, as Mr. Tschernishew is, considers the entire middle division of the

productus-limestone as identical with the permo-carboniferous beds of the Southern Ural. At the time of publication of Mr. Tschernishew's work, however, there had as yet nothing appeared of the Salt-range work, except the special description of the species, and all conclusions as to the distribution of the single forms had to be gathered with great painstaking from the scattered indications in the text. Thus Mr. Tschernishew was barely in a position to make out the fact that there had to be distinguished several sub-divisions within the middle productus-limestone.

The species contained in this middle division of the middle productus-limestone and identical with those of the permo-carboniferous beds of the Ural are the following:—

Athyris royssii, Lév.
Spirifer wynnei, W.
„ *musakhelensis*, Dav. (=*fasciger*, Keys.)
Spiriferina cristata, Schl.
Martinia semiplana, W.
Orthis cf. *indica*. W.
Productus lineatus, W.
„ *cora*, Orb.
Marginifera typica, W.

Of these again, *Athyris royssii*, *Spirifer musakhelensis*, *Spiriferina cristata*, *Productus lineatus*, and *Prod. cora* are ubiquitous, and cannot be considered as leading. *Orthis indica* and *Marginifera typica* occur also in the next lower beds, and thus there remain only *Spirifer wynnei* and *Martinia semiplana*, which are characteristic of the middle division of the middle productus-limestone; but just these two only have been quoted by Tschernishew, with a query, from the Artinsk beds.

So, as I have told already above, it becomes probable that the permo-carboniferous beds of the Ural have on the whole been rightly parallelised with the lower and middle productus-limestone by Tschernishew, as far as the data were then available; but that upon a closer examination such a parallelisation can only be retained for the lower and the lowest beds of the middle productus-limestone, whilst the middle division of the latter stage must be considered as on a higher level.

This becomes chiefly evident from a consideration of the other constituents of the faunæ in both cases. In the brachiopoda fauna of the permo-carboniferous beds of the Ural, 20 of the 34 species are identical with such of the upper carboniferous limestone; whilst in the middle division of the middle productus-limestone, only 7 among 74 species of brachiopoda are identical with such of the upper carboniferous limestone: at the same time a great number of permian species is to be recorded in this fauna (15 among 137 species).

These permian forms are of great geological interest; but as the different species are of very different geographical distribution, it appears necessary to discuss

each of them separately. There are, before all, a number of species identical with such from the typical permian deposits of Central Europe. These are—

Pseudomonotis garforthensis, King.
Camerophoria humbletonensis, Howse.
Spiriferina cristata, Schloth.
Synocladia virgalacea, Phill.
Thamniscus dubius, Schl.
Acanthocladia anceps, Schl.
Spirorbis helix, King.
Geinitzella columnaris, Schl.

Each of these occurs in the true zechstein or magnesian limestone of Germany or England, and therefore they seem to point to rather high horizons within the permian system. There are, however, many reasons why these Salt-range strata cannot be considered in any way directly as equivalents of the magnesian limestone, but the intermingling of these permian species with numbers of permo-carboniferous forms rather points, if there be at all the question of a parallelisation with permian beds, to a position within the system at the very base of it.

Those species which are identical with such as occur in the permian of Russia point to a similar position. These are—

Camerophoria superstes, Vern.,
Athyris royssii, Lév.,
Spiriferina cristata, Schl.,
Productus tumidus, W.= *Prod. cancrini*, (Vern.) Tschernishew.

to which perhaps *Athyris sub-expansa*, W., should be added.

All these species have been excellently described by Tschernishew in his paper on the "Permian limestone of the Government Kostroma", though with regard to the distinction of species he does not always perfectly agree with me.

There remain only some words of explanation with regard to two species. *Productus tumidus*, as figured by me, shows on a first glance very strong similarities to the figure given by Tschernishew of *Prod. cancrini*, Vern. The same fine wavy lines, the same irregular distribution of spines, are exhibited by both figures. Whether there exists, however, a real identity, I am not able to decide, as no authentic specimens of the Russian form are at my disposal for comparison.

The same is the case with regard to *Athyris subexpansa*. I have distinguished this species from *Athyris royssiana*, Keys, on account of the absence of expansions all round the shell, which have been mentioned by some of the most eminent palæontologists as essential for the recognition of the species. Mr. Tschernishew, however, seems not to lay any stress on this character, and describes in his paper on the permian of the Gouvernement Kostroma, shells under the name of *Athyris royssiana*, which seem to be in all respects similar to my *Athyris subexpansa*.

Howsoever these questions may turn out, the assemblage of Russian permian species in the middle division of the middle productus-limestone shows at all events a certain affinity to the fauna contained in the permian limestones of Kostroma. These latter strata have now been considered in Russia to be on a lower level than the great bulk of permian beds as exposed in Perm, and thus as being intermediate between the permo-carboniferous beds of the Ural and the typical permian strata.

A similar position seems also the most probable one for the beds of the Salt-range here under consideration. This opinion is yet strengthened by a number of other species which also occur in these beds. These are—

Nautilus peregrinus, W.
Oxytoma atavum, W.
Pecten wynnei, W.
Hemiptychina inflata, W.
Oldhamina decipiens, Kon. sp.

Though there is no species among them which would be identical with any from foreign countries, yet they are of special interest on account of their relations to forms which have been found up to the present only in secondary deposits.

Naut. peregrinus as well as *Oxytoma atavum* are most nearly related solely to jurassic species, whilst *Hemiptychina inflata* has its nearest relation in *Hemiptych. renierii*, Cat., out of Italian and Southern Alpine liassic beds. The species of true pecten, like *Pect. wynnei*, does not generally begin to appear below the trias, and the genus *Oldhamina* has its nearest relation in the genus *Pterophloios*, Gümb., from the rhætic of Europe.

So we see that this whole group of forms gives a very recent aspect to the fauna under consideration. Thus also from this point of view it appears improbable that the middle division of the middle productus-limestone should yet be included with the permo-carboniferous group of rocks; but here already begins the dawn of a new order of things in preparation for the final appearance of the Mesozoic era.

Starting also from these considerations, it appears advisable to consider the sub-division under consideration as forming the lowest division of the permian system in the most restricted sense.

In Central Europe, it is well known that the permian system is initiated by the "Rothliegende;" so that the middle division of the middle productus-limestone must be about on a level with that formation: but to say anything more on the matter is impossible.

In peninsular India this sub-division must fall homotoxically within the scope of the Damuda formation, but what member of it may be contemporaneous it is impossible to say.

Also in the Himalayas, we have as yet no record of any distinct equivalent of the beds here under consideration: most probably such an equivalent must be looked for somewhere within the Kuling shales. Of the white crinoidal limestones of the

Milam pass, there has been this question already on a former occasion. On the whole, the fauna of these limestones is not dissimilar to that of the present sub-division, but the presence of *Productus semireticulatus* gives it a slightly more ancient aspect.

c. Upper Division of the Middle Productus-limestone.

In most of the sections in which the middle productus-limestone is well developed, there follows above the compact limestones of the middle division a marly series, composed of grey or sometimes somewhat greenish marls, strongly siliceous and intercalated with thin limestone bands. The fossils are beautifully silicified, most emimently so at Musakhel, and are generally very numerous. The thickness of this marly series is generally not very considerable. It varies between ten and fifty feet, though this latter thickness is but rarely attained.

This sub-division finds its strongest development in the trans-Indus continuation of the Salt-range, where I myself have observed it in the Khasore-range at Kaffir Kote. The section I have there taken down is represented in the following figure :—

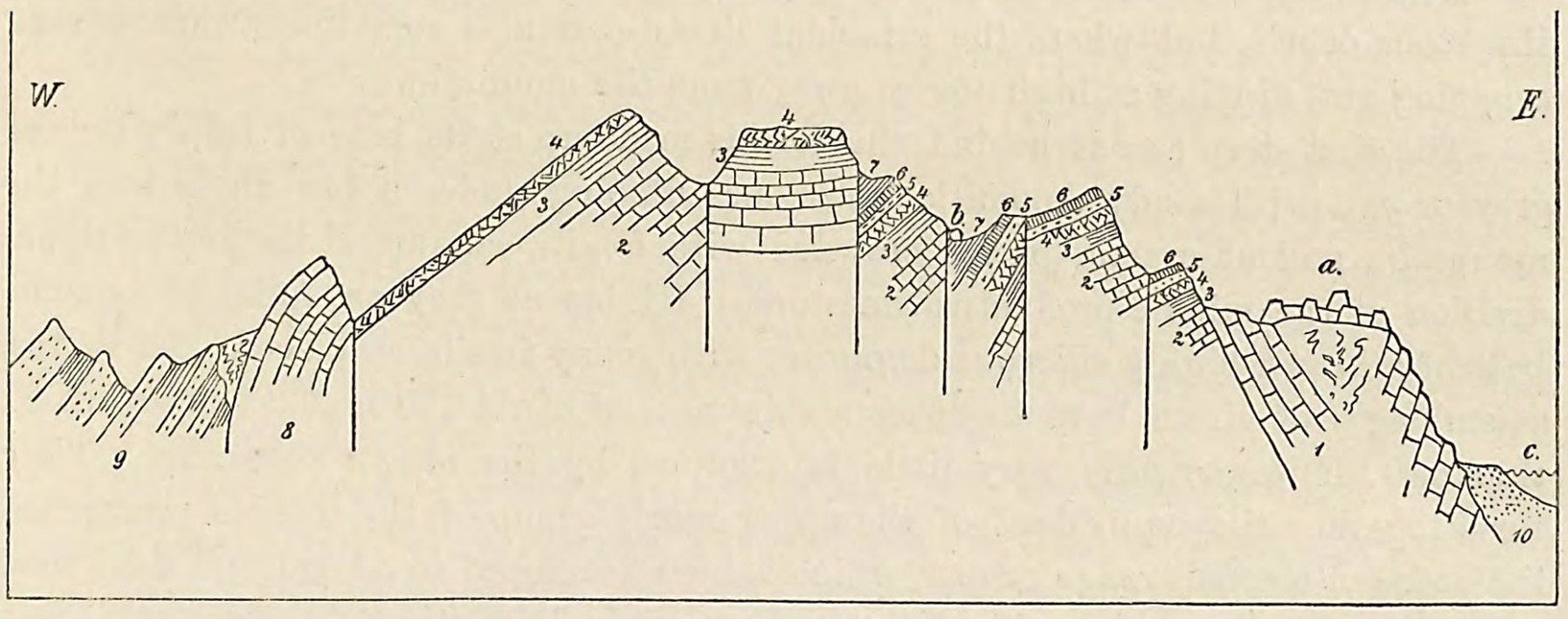


Fig. 8. Section through the Khasore-range at Kaffir Kote, showing the strong development of the upper division of the Middle Productus-limestone, and the considerable reduction of the Upper Productus-limestone.

1. Thick white coral limestones (lower region of the middle division of the Middle Productus-limestone) ; 2, thin-bedded siliceous limestones (upper region of the middle division of the Middle Productus-limestone) ; 3, dolomitic sandy beds (upper division of the Middle Productus-limestone) ; 4, rusty dolomites; 5, yellow sandy dolomitic beds (Upper Productus-limestone) ; 6, ceratite limestones ; 7, ceratite marls; 8, nummulitic limestone ; 9, orange series (lower part of the Middle Siwaliks) ; 10, alluvium of the river Indus. *a*, ruins of the fort of Kaffir Kote ; *b*, Native huts ; *c*, river Indus.

I came from Mianwalli in a long march down to Hirawalli Kachhi, where I crossed with great difficulty on horse-back the river Indus, arriving directly at the high scarp on which the very imposing ruins of an old fort, surrounded by huge ramparts and defended by square and round towers, are situated.

The scarp itself, which, at high flood, is directly hit by the waves of the river, is composed of thinly-bedded grey or brownish or greenish strongly siliceous limestones, nearly vertical but dipping slightly into the mountain, with many fos-

sils, among which *Productus lineatus*, W., and *Productus indicus*, W., were observed. It is impossible to ascend the scarp, but by turning a little to the north, where the original ascent to the fort was situated, traces of the old quarries, from which the materials for the building of the fort have apparently been taken, can be observed.

These quarries have been opened in hard white crinoidal limestones, which ring loudly under the hammer, in thick beds, nearly vertical in their position or dipping a little in the opposite direction to the thinly-bedded limestones mentioned before, that is to say, away from the mountain.

The terrace on which the fort is built is made up of these two sorts of limestones.

In reaching the fort, one enters it by a large tunnel-like doorway that pierces the rampart in an ascending direction, following at the same time a laterally broken line. Inside, there are besides heaps of rubbish, four more or less well-preserved and richly sculptured temples, several dried-up tanks with neatly set staircases leading down to their bottom, and one corner of a palace-like building with two floors and large square windows, the surroundings of which are so neatly carved with pillars and ornaments that the whole strongly reminds one of Greek architecture.

Behind the fort there extends a slightly ascending space, mostly covered by limestone débris, but where the crinoidal limestones also sometimes can be seen cropping out, dipping at high angles away from the mountain.

The first steep ascent behind the fort is made up at its base of thinly-bedded grey or yellowish sandy dolomitic limestones dipping under a low angle into the mountain, and at certain places crowded with fossils, characteristic of the upper division of the middle productus-limestone. Higher up they are followed by some beds of a brown highly siliceous dolomite, with many fossils at places. These two assemblages of strata have together a thickness of about 150 to 200 feet, of which thickness, however, only very little is occupied by the brown dolomites. They form together the equivalent of the upper marly group of the middle productus-limestone of the Salt-range proper, which is here developed to an unusual thickness.

Above the brown dolomites follow yellow sandy dolomitic beds of about 30 feet thickness, which represent the upper productus-limestone, here very much reduced; and these are covered again by very thinly-bedded, excessively hard grey limestones of the ceratite, or triassic epoch.

With this layer the first step behind the fort is closed. A little plain succeeds, after which the mountain again ascends. The first beds that are met with here are thickly-bedded, grey siliceous limestones rich in fossils at places. I collected there *Chonetes squamulifera*, W., *Strophalosia rarispina*, W., *Chonetella nasuta*, W., *Productus lineatus*, W., *P. indicus*, W., *Marginifera typica*, W., *Richthofenia lawrenciana*, Kon., and *Polypora megastoma*, Kon. Above these limestones, which are between 200 and 250 feet thick, follows again the same grey or yellowish sandy dolomitic limestone series, which was met with at the foot of the first step. Here, however, the collecting of fossils is much more feasible, as the slope is less steep, and it is thus easier to get a footing on it. The fossils seem to be

distributed rather regularly in single horizons, but the time at my disposal was too limited to make any safe observations in this respect. Only one bed was too conspicuous to be overlooked; this was a thin bed of a reddish brittle crinoid limestone, about a foot or a foot and-half thick, situated high up in the series, not far from the brown dolomites by which the whole series comes to a close. This bed was filled with hundreds of specimens of *Spirigerella alata*, W., which species I observed nowhere else in the whole Salt-range except on this single spot.

Of other species, I collected in this dolomitic sandy series, in which, however, silica is rather sparingly distributed, the following: *Hemiptychina himalayensis*, Dav., *Notothyris subvesicularis*, Dav., *Not. warthi*, W., *Camerophoria purdoni*, Dav., *Spirigerella derbyi*, W., *Athyris capillata*, *Eumetria grandicosta*, Dav., *Spiriferina cristata*, Schl., *Spirifer musakhelensis*, Dav., *Streptorhynchus pectiniformis*, Dav., *Productus lineatus*, W., *Prod. indicus*, W., *Prod. abichi*, W., *Marginifera typica*, W.

The brown or rusty dolomites following above this series are about 15 or 20 feet thick, and very strongly siliceous. Against the general rule, they are here rich in fossils, though it is not easy to detach these from the rather hard rock. I collected *Productus lineatus*, W., *Productus indicus*, W., and *Productus tumidus*, W.

These dolomites are again followed, as in the first step, by a comparatively thin set of beds, representing the upper productus-limestone, and then by the thinly-bedded ceratite limestones forming the lowest number of the triassic strata.

The terrace which now follows is formed first by these latter limestones in a regular position; then appears again the upper productus-limestone dipping under a very high angle towards the mountain, which is again followed by the ceratite limestone and the ceratite marls the second member of the triassic series. These latter cause a little valley to be formed, full of verdure, with a few fields and a miserable hamlet of native huts.

The next ascent shows again a repetition of the same beds, at the base some of the compact grey siliceous limestones of the middle division, and above these the dolomitic series of the upper division of the middle productus-limestone, then the upper productus-limestone, the ceratite limestone and the ceratite marl, forming again a little terrace. All these beds dip at a low angle towards the mountain, *i.e.* towards the west or south-west.

After this, a new step commences, which is, however, composed of perfectly horizontal beds. The same strata are again repeated as far as they belong to the middle productus-limestone, the higher beds being altogether absent. The top of the level terrace now reached is entirely composed of the brown or rusty dolomites.

After this follows a deep khud, difficult of access; and now the ascent of the highest summit of the range (2,124 feet) commences. Again, the same rocks, the compact limestones of the middle division and the upper division of the middle productus-limestone, are crossed; and after having reached the summit one finds the rusty dolomites covering the whole western slope of the range.

It was evening when I reached this spot, and in the mild rays of the sinking

sun I could observe the landscape extending to the west. At the foot of the range extended a sharp ridge, apparently composed of limestones; and then followed a series of sandstone hills, with beds of orange-coloured marls between, evidently representing the orange series or lower part of the Middle Siwaliks. Further west, lay the broad valley separating the Khasore and Mohrut ranges; and behind this rose the Mohrut-range itself in bold outline. To all appearances this seemed to be composed of Dungote sandstone, the upper part of the middle siwaliks.

I now quickly descended to have yet a look at the limestone ridge before me, but all my endeavours were in vain, it was sinking darkness when I reached it, and it was no longer possible to distinguish whether it was composed of permian or nummulitic limestone. A piece of rock I had given one of the servants to carry away was thrown by him afterwards on the road and thus all determination was frustrated.[1]

As the country was considered not very safe, I had now to hasten back over the mountain to the ruin, where my horse was waiting for me at a Jogi's hut, which was situated very picturesquely between the foot of the hill and the river bank near a spring, hidden in a grove of palm-trees. I had to recross the river and arrived at last late at night and thoroughly wetted in my camp.

If one compares this section with the one given on p. 181 of the same beds in the vicinity of Khura, one will easily see what great differences exist between the two. Thus also in these beds a great amount of variation takes place, but this variation is more local. All the eastern parts, or better, all the localities in the Salt-range proper, to which also the exposures at Kalabagh must be added, show a development similar to that at Khura, whilst at most of the trans-Indus localities a development similar to that at Kafir Kote seems to prevail.

The fauna that has been detected up to the present in these beds is the following:—

*** *Xystracanthus gracilis*, W.[2]
* *Nautilus flemingianus*, Kon.
* „ *connectens*, W.
* *Gyroceras medlicottianum*, W.
* *Orthoceras punjabiense*, W.
** *Euomphalus parvus*, W.
* *Naticopsis khurensis*, W.
* *Platystoma indicum*, W.
***** *Pleurotomaria punjabica*, W.
*** *Bellerophon blanfordianus*, W.
*** *Euphemus indicus*, W.
*** *Stachella bifrons*, W.

[1] According the Mr. Wynne's map, the ridge must be composed of mummulitic limestone.

[2] As in other lists; * signifies species peculiar to the sub-division, ** species coming from below, *** species extending above, ***** species coming from below and extending above.

* *Loripes proavius*, W.
*** *Pleurophorus subovalis*, W.
*** *Nucula trivialis*, Eichw.
** *Macrodon geminum*, W.
** *Pseudomonotis garforthensis*, King.
** *Dielasma biplex*, W.
** „ *problematicum*, Dav.
*** *Dielasmina plicata*, W.
** *Hemiptychina sparsiplicata*, W.
***** „ *himalayensis*, Dav.
***** „ *inflata*, W.
*** *Notothyris subvesicularis*, Dav.
* „ *djulfensis*, Ab.
***** „ *warthi*, W.
* „ *lenticularis*, W.
** „ *minuta*, W.
** „ *multiplicata*, W.
** *Lyttonia nobilis*, W.
** „ *tenuis*, W.
***** *Oldhamina decipiens*, Kon.
** *Terebratuloidea davidsoni*, W.
* „ *depressa*, W.
*** *Uncinulus theobaldi*, W.
*** „ *jabiensis*, W.
*** *Rhynchonella wynnei*, W.
***** *Camerophoria purdoni*, Dav.
***** *Spirigerella derbyi*, W.
*** „ *hybrida*, W.
***** „ *minuta*, W.
***** „ *grandis*, W.
***** „ *media*, W.
*** „ *ovoidalis*, W.
* „ *alata*, W.
***** *Athyris royssii*, Lév.
***** „ *subexpansa*, W.
***** „ *capillata*, W.
***** *Eumetria grandicosta*, Dav.
***** *Spiriferina cristata*, Schl.
*** „ *multiplicata*, Sow.
***** *Spirifer musakhelensis*, Dav.
** *Martinia elongata*, W.
** „ *warthi*, W.
*** *Reticularia indica*, W.

* *Enteletes lævissimus*, W.
* ,, *latesinuatus*, W.
** *Orthis derbyi*, W.
** ,, *indica*, W.
***** *Streptorhynchus pectiniformis*, Dav.
***** *Derbyia grandis*, W.
*** ,, *hemisphærica*, W.
***** *Chonetes squamulifera*, W.
* *Strophalosia excavata*, Gein.
***** ,, *rarispina*, W.
***** *Chonetella nasuta*, W.
* *Aulosteges dalhousi*, Dav.
***** *Productus lineatus*, W.
***** ,, *indicus*, W.
***** ,, *gratiosus*, W.
***** ,, *abichi*, W.
*** ,, *purdoni*, Dav.
***** ,, *tumidus*, W.
***** *Marginifera typica*, N.
***** *Richthofenia lawrenciana*, Kon.
** *Fenestella perelegans*, Meek.
*** ,, *jabiensis*, W. & T.
***** *Polypora koninckiana*, W. & T.
** ,, *megastoma*, Kon.
***** *Cyathocrinus goliathus*, W.
***** *Geinitzella columnaris*, Schl.
***** *Lonsdaleia indica*, W. & W.
***** *Hexagonella ramosa*, W. & W.
***** *Dybowskiella grandis*, W. & W.
*** ,, *expansa*, W. & W.
** *Fistulipora parasitica*, W. & W.
** *Amblysiphonella vesiculosa*, Kon.

Altogether 78 species, of which, however, not more than 15 are peculiar to this upper sub-division of the middle productus-limestone. Fifty-three of them come up from lower beds, whilst 52 others extend into higher strata; among these are again 34 which extend through the greater part of the Productus-limestone from the base to the top, and these must be deducted if we wish to find out how many species terminate and how many commence in this sub-division. Thus we find that 19 species have their last representatives in this sub-division, whilst 18 others take their origin here and extend thence into higher strata.

From all this, it appears that the fauna of these strata exhibits a truly transitional character, and that it must be questioned whether this sub-division may be

retained on patæontological grounds. In this respect it must not be forgotten that the greatest part of those species that exhibit a wide geological range are *Brachiopoda*, which very generally do not keep strictly to an exact geological horizon and therefore can be used only in rare cases as reliable documents for the identification of a narrowly limited geological stage or zone. Among the species, on the other hand, that are peculiar to this sub-division, there are all the *Cephalopoda*, some *Gasteropoda* and bivalves, forms which are generally much better adapted for the characterisation of narrowly limited horizons than the *Brachiopoda*.

Taking all this into consideration, it appears probable that the present sub-division, though it cannot exactly be considered as a proper sub-division, but on the whole may perhaps be better taken as forming part of the same sub-division to which the middle division of the middle productus-limestone belongs; so that the two would form together only one group, yet it should be considered as forming a proper geological horizon, which in time may furnish a very characteristic and well distinguishable cephalopod fauna.

With this sub-division the middle productus-limestone comes to a close. It is barely of any use to go again into details about the equivalents of this sub-division in foreign countries, as it is in its fauna so little different from the one next lower in the series that we should come to the same results; that is to say, this sub-division must be placed also approximately on the level of the lowest permian or on a level with the beds exposed in the Gouvernement Kostroma, or with the Rothliegende of Central Europe, and perhaps a little higher, the Weissliegende and marl-slate.

There is, however, yet one parallelisation to be discussed, which I have deferred up to this moment, and this is the comparison of the Salt-range deposits with the upper coal measures of North America.

The relations that undoubtedly exist between the American coal measures and the deposits of the Salt-range are nothing less than striking; and it has not seemed to me advisable to give a comparison of the fauna of each single sub-division with corresponding beds of America, because the similarity that exists rests much more in the general character of the faunæ than in the identity of single species, and just this general character can be discerned much more strikingly if larger groups of rocks can be compared in this respect than small sub-divisions.

When I commenced my work on the Salt-range, there were two absolutely opposite opinions prevailing with regard to the age of the beds composing the upper coal measures of North America. Some believed them to reach up so high in the series as to form partly an equivalent of the permian of Europe; whilst others, and this was the majority, considered them as thoroughly and entirely carboniferous. There was, however, a third party who considered the topmost beds already as triassic; so that it remained very doubtful whether any equivalents at all of the European permian strata occurred in America.

The question was taken up again with great success quite recently by Dr. Ch. White, the celebrated palæontologist of the United States Geological Survey.

He has shown quite clearly that in America conditions of deposition prevailed

very much different from those existing in Europe and elsewhere; and that the peculiarities of the American deposits consist chiefly in the circumstance that the single species of invertebrate animals have a very much longer duration in America than we are generally wont to observe in other countries. This circumstance therefore is the cause that no such strict divisional lines can be drawn during the entire carboniferous epoch, as it is generally possible to distinguish between different systems or formations.

To a certain extent a similar fact has come to light also in Europe, since the geological investigations in Russia have been taken up with such order; yet the vertical extent of the single species is more limited here than in America. In Russia the truly carboniferous forms do not extend into the truly permian strata, but stop at the base of the Kostroma beds; whilst in America this is not the case, for they extend here through the entire permian, and even apparently partly into beds which have generally been considered as triassic.

The chief character on which a distinction between the permian and carboniferous systems may be drawn is here apparently in the general colour of the beds, a character which was long ago pointed out by M. Marcou, but which has been rejected generally on palæontological grounds, because the greatest number of species extends indiscriminately through all the deposits.

The lower beds belonging to the carboniferous system have in general a grey or greenish colour, whilst the upper beds, composing the permian system, are in general of a red colour. Both, however, are composed of sandstones and shales with some intercalated limestones.

That the red beds, though yet enclosing numerous carboniferous species, are in reality the equivalent of the permian of Europe, has been proved conclusively by Dr. Ch. White's new discoveries in these beds in Texas.

In strata, where the change of the faunæ does not hold good for the distinction of single horizons, one must get hold of other characters in order to make out the development of the general sequence of formations, as they have been distinguished in other countries. Such a character has now been found out by Dr. White in the admixture of the fauna of ubiquitous species of elements, which are strangers in this fauna and which at different horizons show different characters.

Dr. White's investigations were chiefly directed towards the deposits of Texas; and these rocks were already beforehand remarkable on account of Dr. Cope's discoveries in them of numerous amphibians and reptiles which exhibited decidedly permian characters, and which therefore were also declared unhesitatingly by Dr. Cope as of permian age. The invertebrate fauna of these beds had not been made known up to then, and it is Dr. White's merit to have investigated also this part of the fossil contents of these deposits.

Dr. White encountered the following determinable species:—

Orthoceras rushensis, McChesn.
Nautilus winslowi, M. & W.
„ *occidentalis*, Swall.

Naticopsis remex, Wh.
„ *shumardi*, McChesn.
Euomphalus sub-quadratus, M. & W.
Bellerophon crassus, M. & W.
„ *montfortianus*, N. & T.
Sedgwickia topekaensis, Shum.
Clidophorus occidentalis, Gein.
Yoldia subscitula, M. & W.
Myalina permiana, Swall.
„ *aviculoides*, M. & H.
„ *perattenuata*, M. & H.
Gervillia longa, Gein.
Aviculopecten occidentalis, Shum.
Cythere nebrascensis, Gein.

All these species are well known coal-measure forms. Intermingled with these, however, were found things exhibiting a quite different character; these are:—

Medlicottia copei, White n. sp.
Popanoceras walcotti, White n. sp.
Ptychites cumminsi, White n. sp.

Such remains have as yet never been found in truly carboniferous strata. The geologically oldest species of the genera *Medlicottia* and *Popanoceras* have been detected up to the present in the topmost beds of the permo-carboniferous of the Ural, while these genera have their chief development in the Fusulina-limestones of Sicily, which are most probably of a lower permian age. *Ptychites cumminsi*, however, is a quite peculiar fossil. It can only be compared to the *Hyattoceras* of Sicily, but deviates from the Italian species of the genus by a remarkably strongly developed lower lateral ramus of the siphonal lobe. The genus *Hyattoceras*, however, is absolutely absent in truly permo-carboniferous strata, and makes its first appearance in the permian.

From all this it appears that the beds in which these cephalopoda occur cannot be lower in the series than permian, notwithstanding all those coal-measure species which have been quoted above.

A similar fact was brought to light long ago by M. Marcou in Nebraska, where in the lowest beds of the red series a fauna had been detected by him, which afterwards was declared to be permian by Prof. Geinitz. Though the latter learned author's determinations of species have afterwards for the greater part been drawn into doubt by Meek and Worthen in their final report on Nebraska; yet even these authors must admit for certain forms their permian affinities: and thus, after carefully considering all the circumstances, we come to admit the occurrence of the following European permian species in the deposits (chiefly "C" of M. Marcou's section) of Nebraska city:—

Solemya biarmica, Vern.
Schizodus truncatus, King.

Schizodus rotundatus, Brown.
„ *rossicus*, Vern.
„ *obscurus*, Sow.
Nucula kazanensis, Vern.
„ *beyrichi*, Schaur.
Clidophorus costatus, Brown.
„ *simplus*, Keys.
Pseudomonotis radialis, Phill.
„ *speluncaria*, Schl.
Productus cancrini, Vern.
„ cf. *horridus*, Sow.
Polypora biarmica, Keys.
Gulielmites permianus, Gein.

The number of these species is very insignificant as compared wiih the great number of coal-measure species occurring in the same beds; but considering the great distance from all typical permian strata and the general observation that can be made in all the American carboniferous deposits, that the single species have a very much wider geological range than is generally the case in other countries and deposits, we must lay a greater stress on these species than would otherwise be the case, and we may be justified if we consider the beds of Nebraska city, as well as the red amphibian-bearing series of Texas, as belonging to the permian system.

What position these strata may occupy within this system is rather difficult to tell. If we consider, however, the degree of development attained by the single species of the Texan cephalopoda, we come to the conclusion that it is by far more probable that the lower permian may be represented by these beds than the upper one; a fact that has been recognised already by Tschernishew for the deposits of Nebraska city, which he places on a parallel with the beds of Kostroma.

The permian deposits of W. Virginia and S. W. Pennsylvania, which have furnished, as far as is known to me, no marine fossils, but only a distinctly permian flora containing among other species *Odontopteris obtusiloba*, *Callipteris conferta*, *Alethopteris gigas*, etc., need not be considered here in detail. They follow regularly above the productive coal-measures and are known under the designation of the "Barren measures."

The beds that in general have been designated as upper coal measures by American authors are, however, not only restricted to North America: they seem to occupy also rather extended areas on the South American continent. The best known country in this respect is on the Rio Tapajoo in Northern Brazil, north of the Amazons. The beds here have been excellently described by Prof. Derby, now of Rio de Janeiro, in the Bulletin of the Cornell University. These beds seem to be rather high in the series, as *Strophalosiæ* are of frequent occurrence and among the *Producti* there are some which come very near to *Productus horridus*. At the same time, however, also *Productus semireticulatus* is not absent, and this assem-

blage of forms is suggestive of an age for these beds, just at the limit between the permo-carboniferous and permian groups of rocks.

Another country where the upper coal measures seem to occur in great force is in the Andes, where chiefly in the surroundings of lake Titicaca numerous fossils have been found. The greater part of d'Orbigny's originals came apparently from these beds, and thus *Productus cora, humboldti, Enteletes andium*, etc., must be considered as originally described from the strata of the upper coal measures. That the genus *Terebratuloidea* is of frequent occurrence there has been demonstrated by the figures by Prof. Toula of specimens from lake Titicaca. How far these beds may be attributed partly to the permian, the permo-carboniferous, or the carboniferous proper is impossible to decide at present. To the deposits of Brazil we shall, however, have occasion to recur yet later on in the text.

Now the deposits of the Salt-range show in general a certain affinity to those of America, though this affinity is by no means very striking. There are, it is true, some identical species, but their number is very limited. These species are the following:—

Dielasma itaitubense, Derb.
Spirigerella derbyi, W.
Athyris royssii, Lév.
Spirifer marcoui, W.
Reticularia lineata, Mart.
Orthis pecosii, Marc.
Productus lineatus, W.
„ *cora*, Orb.
„ *semireticulatus*, Mart.
„ *humboldti*, Orb.
Fenestella perelegans, Meek.

The peculiarity which, before all, will strike the reader in this list is, that it is entirely composed of species which are either entirely restricted to the lower and middle productus-limestone, or else have got at least their chief development in these divisions. Only four forms—

Schizodus rotundatus, Brown,
Nucula ventricosa, Hall,
Pseudomonotis radialis, Phill.,
Polypora biarmica, Keys,

which also occur in the American coal measures, are restricted in the Salt-range to the upper productus-limestone.

Besides these identical species, there are, however, in the Salt-range yet a number of forms which have their nearest allies in the coal measures of America. These, to a certain extent vicarying species are the following:—

Salt-range.	Coal-measures.
Xystracanthus gracilis, W.	*Xystracanthus acinaciformis*, St. T. & W.

Salt-range.		Coal-measures.
Bucania kattaensis, W.	.	*Bucania marcouiana*, Gein.
Euphemus indicus, W.	.	*Euphemus nodosocarinatus*, Hall.
„ *lævis*, W.	.	*E. carbonarius*, Cox.
Cleidophorus trapezoidalis, W.	.	*Cleidophorus oblongus*, M. & H. sp.
Pseudomonotis kazanensis, Ver.		*Pseudomonotis hawni*, M. & W.
Avicula chindonensis, W.	.	*Avicula sulcata*, Gein.
Lima footei, W.	.	*Lima retifera*, Shum.
Aviculopecten sub-exoticus, W.	.	*Aviculopecten hawni*, Gein.
Euchondria subpusilla, W.	.	*Euchondria neglecta*, Gein.
Eumetria grandicosta, Dav.	.	*Eumetria mormonii*, Marc.
Spiriferina vercherei, W.	.	*Spiriferina transversa*, M'Chesn.
Spirifer musakhelensis, Dav.	.	*Spirifer cameratus*, Mort.
Enteletes kayseri, W.	.	*Enteletes hemiplicatus*, Meek.
„ *ferrugineus*, W.	.	„ *andii*, Orb.
Orthis derbyi, W.	.	*Orthis morganiana*, Derb.
„ *corallina*, W. „ *nicisiva*, W.	.	„ *pecosii*, Marc.
Streptorhynchus deltoidens, W.	.	*Streptorhynchus hallianus*, Derb.
Derbyia vercherei, W.	.	*Derbyia crassa*, M. & H.
Chonetes morahensis, W.	.	*Chonetes geinitziana*, W.
„ *strophomenoides*, W.	.	„ *variolata*, Orb.
„ *compressa*, W.	.	„ *flemingi*, Norw. & Pratt.
Strophalosia rarispina, W. „ *indica*, W.	.	*Strophalosia cornelliana*, Derb.
Productus gratiosus, W.	.	*Productus portlockianus*, Norw. & P.
Marginifera excavata, W. „ *typica*, W.	.	*Marginifera splendens*, Norw. & Pratt.

This is a very mixed assemblage of species, ranging through the entire productus-limestone. There can, however, well be distinguished two sets of forms: there are among them 19 which occur in the Salt-range in the middle and lower productus-limestone, whilst there are 10 which characterise the upper productus-limestone. If we yet add to these numbers the identical species, we have for the middle and lower divisions of the productus-limestone just 30 species identical or allied, of which by far the majority belongs to the middle productus-limestone, whilst in the upper productus-limestone there are only 14 identical or allied with such of the coal measures of America.

Regarding, on the other hand, the distribution of the American species, there are 15 out of Division C of Marcou's section of Nebraska city, whilst the other 10 occur either in Brazil or in lower strata of the North American coal measures.

From all this we may conclude that the upper coal measures of America are not only the equivalents of the so-called permo-carboniferous strata, or, that is to

say, of the speckled sandstone group of the Salt-range, but extend also into yet higher horizons, which most probably correspond not only to the middle productus-limestone, but also perhaps yet to a certain part of the upper productus-limestone.

In the discussion of the probable age of the coal-measure strata of America, I had already several times occasion to allude to certain beds of Northern Brazil, in which numerous specimens of *Strophalosia cornelliana*, Derb., had been detected. The occurrence of these *Strophalosiæ*, as well as the distribution of the genus *Strophalosia* in general, is of special importance and needs a yet more explicit discussion. The species *Strophalosia cornelliana* has two near allies in the Salt-range: *Stroph. rarispina*, W., and *Stroph. indica*, W. Of these two species, one occurs in the middle and upper, and the other only in the upper productus-limestone. Also the other brachiopoda that have been found at Itaituba and have been described by Derby, point to a relation of these beds nearly exclusively with the middle and upper productus-limestone. Thus it becomes highly probable that the beds exposed at Itaituba are in reality to be placed on a level with the permian of Europe. This is of very great importance for the entire geology of Brazil, as we shall see in the sequence.

The case is quite different with regard to other *Strophalosiæ* which have also their nearest relation in the Salt-range, and these are *Strophalosia gerardi* and its allies, which occur in great numbers in certain beds of Australia. In Queensland, in the Bowen river coal field, there occur two species of *Strophalosiæ*: *Stroph. clarkei*, Eth. jun., and *Stroph. gerardi*, King, which have very near relations in the Salt-range, the group being represented there by *Strophalosia plicosa* W., *Stroph. nodosa*, W., and *Stroph. tenuispina*, W.

The third Australian species of *Strophalosia*: *Strophalos. jukesi*, Eth. jun., which occurs in the marine beds of New South Wales and Tasmania, deviates very far from the former by its internal characters.

Now the mentioned species of the Salt-range belong all three to the fauna of the lower productus-limestone or upper speckled sandstone, and thus this group of *Strophalosiæ* points evidently to a much lower geological horizon than the group of forms which is represented in the Brazilian strata.

We have formerly seen that the marine beds of New South Wales must be placed probably on a level with the lower speckled sandstone boulder beds or the talchirs of peninsular India; and the coal beds or Newcastle series, which follows next higher in the sequence, have probably got their representative in the Salt-range in the middle speckled sandstone. Now these two series seem (the one entirely, the other partly) to be apparently absent in Queensland, as the Bowen river coal-field series rests here unconformably directly on the Mount Wyatt beds, which are, according to Etheridge Sen. and Feistmantel, upper devonian, though at other places carboniferous strata with *Prod. cora* and plant-remains seem to intervene; but the discordance holds nevertheless good. With these facts, the relations that exist between the *Strophalosiæ* there and those of the Salt-range would be well in accordance; so that probably the Bowen river coal-field series should be placed either

on a level with the lower productus-limestone or else should be considered as forming partly an equivalent of the lower half of the middle productus-limestone.

A permian age has also already been advocated by Etheridge, Jun., for the Bowen river series.

Thus we have now followed the probable equivalents of the middle productus-limestone over the greater part of the surface of the globe. Only one more important territory has not been touched upon, and this is the Arctic territory. As, however, the development of these strata in the Arctic regions is very similar to the one prevailing in North America; and as the discussion has become already very long, I think that perhaps I may be excused for neglecting this area.

UPPER PRODUCTUS-LIMESTONE.

Already in the introductory notes to the siliceous limestone group, it has been stated that the petrographical differences between the single sub-divisions are but very small within this group.

In the middle productus-limestone we have seen that there are yet some slight differences, but in the upper productus-limestone such differences are altogether absent, and the sub-divisions can be founded exclusively upon palæontological data.

As a proof of this I may be allowed to put down here part of a section that I have measured at Chidru. The section was measured by me chiefly with a view to ascertain the different horizons existing within the ceratite formation; but, as the upper productus-limestone was also well exposed, I extended the section down to these beds.

As far as it interests us at this moment, the section runs as follows:—

Ceratite beds, lowest part.		Grey thinly-bedded limestones with many ceratites .	10 feet.
Upper Productus-limestone.	Topmost beds.	Yellow, soft sandstones with harder concretions and countless fossils	10 „
	Cephalopoda beds.	Brownish or greyish dolomitic sandstones, alternating with marly beds, in the lower region a bed full of *ceratites*	60 „
	Lower beds	A somewhat more yellowish series of the same description	60 „
Middle Productus-limestone.	Upper division.	Grey shales with some harder limestone beds strongly siliceous	10 „
	Middle division.	White compact siliceous limestones . . .	200 „

The sub-divisions introduced by me in the upper productus-limestone are more or less arbitrary. The occurrence of *Ammonites* and *Ceratites* in company with palæozoic forms of *Brachiopoda* in great numbers was a very startling fact at the time of my visit to the Salt-range; a fact that has been questioned even years later by M. Barrande. Therefore my special attention was directed towards the mode of

occurrence of those *cephalopoda* and their association with other fossils. I soon found that chiefly the *ceratites* were to be met with more numerously than elsewhere in certain beds, that I generally found to hold a position a little above the middle of the whole formation.

I now labelled the fossils I found in and above the Cephalopoda beds separately; whilst the others, collected in lower positions, were again kept separate.

Though at this moment the occurrence of *Ammonites* and *Ceratites*, together with palæozoic forms of *Brachiopoda*, is no longer such an extraordinary fact as it was some fifteen years ago, it will even now not be entirely without interest to see how the fauna is composed in the lower half of the sandy dolomitic series, where *cephalopoda* resembling *Ceratites* and *Ammonites* are also disseminated but of somewhat rarer occurrence; and what contrast it exhibits to the fauna of the upper half of the same series, where *Ceratites* are often found in great numbers, and the celebrated *Cyclolobus oldhami* has a home. Thus I thought it not convenient, after the distinction had been made in the field, to abolish it in the descriptions of species; and it is also kept up here in order that every body may be able to judge of its worth. In this respect it will, however, be convenient to keep in mind that the materials collected in the Salt-range are composed only of specimens that have been picked up by chance in visiting a certain locality a single time, and that no systematic search of fossils has been instituted for a full account of the single fauna to be available. The indications as to the vertical extension of the single species can thus only be correct as far as the studies reach.

The case is different with the topmost beds. These form distinctly a layer for themselves and must be considered as composing a proper sub-division.

The sequence of beds in this region seems, however, not to be quite complete everywhere in the Salt-range, and in many places there are some traces which lead one to suspect that something is absent. I shall return to this point when treating of these deposits in detail.

The geographical distribution of the upper productus-limestone in the Salt-range is a very regular one. It everywhere, beginning at Khoond Ghat, follows regularly above the hard siliceous limestones of the middle productus-limestone, and the petrographical variations within the group are very limited. Sometimes, as at certain places near Katwahi or near Virgal, the beds are transformed into a brownish, pepper-coloured, or into a grey more or less friable sandstone; but generally the group is composed of light yellowish sandy dolomitic strata, impregnated with silica, so that the fossils are always silicified, but mostly in such a manner that only the outer and inner coating of the shells are transformed into silica, whilst the median layers are calcareous. There is generally a regular interstratification of soft marly and harder beds within this group.

Trans-Indus, the group is frequently of less considerable thickness than in the Salt-range proper.

The rusty dolomites that form an occasional member of all the lower groups of the productus-limestone are also here not entirely absent, but their occurrence is

yet more restricted than in the middle productus-limestone. I have observed such beds at Siran-ki-Dok forming there the topmost beds of the group, and at Kafir Kote.

Having thus given the generalities of the group, I can enter upon the special discussion of the single sub-divisions.

a. Lower and Middle Beds of the Upper Productus-limestone.

The transition from the upper division of the middle productus-limestone to the sub-division here under description is a rather abrupt one. The condition of rocks changes rather suddenly, and the yellow dolomitic series makes its appearance without many beds of transition. Nevertheless the change of the fauna does not hold pace with the lithological change, and chiefly the *brachiopoda* are nearly all identical in the upper, as well as in the lower series.

The fauna found in these beds is composed as follows:—

* *Psephodus indicus*, W.[1]
*** *Helodopsis elongata*, W.
** *Xystracanthus gracilis*, W.
* „ *major*, W.
* *Cythere* cf. *elongata*, Must.
* *Popanocerus* (*Arcestes*) *antiquus*, W.
* ? *Arcestes priscus*, W.
*** *Zenodiscus carbonarius*, W.
*** „ *plicatus*, W.
* *Medlicottia wynnei*, W.
* *Nautilus goliathus*, W.
* „ *transitorius*, W.
* „ *wynnei*, W.
*** „ *latissimus*, W.
* „ *convolutus*, W.
* *Orthoceras cyclophorum*, W.
* „ *oblique-annulatum*, W.
* „ *sp. indet.*
***** *Macrocheilus avellanoides*, Kon.
* *Naticopsis indica*, W.
* *Neritomopsis ovulum*, W.
*** *Phasianella arenicola*, W.
*** *Margarita prisca*, W.
***** *Pleurotomaria punjabica*, W.
*** „ *sequens*, W.
*** *Murchisonia conjungens*, W.

[1] In this list; * signifies species peculiar to the sub-division, ** species coming from below, *** species extending above, ***** species coming from below and extending above.

***** *Bellerophon jonesianus*, Kon.
* „ *impressus*, W.
* „ *affinis*, W.
** „ *blanfordianus*, W.
*** „ *triangularis*, W.
* „ *orientalis*, Kon.
* „ *politus*, W.
*** *Bucania integra*, W.
* *Mogulia regularis*, W.
** *Euphemus indicus*, W.
* „ *lævis*, W.
** *Stachella bifrons*, W.
* „ *semiaurita*, W.
* *Macrotheca wynnei*, W.
*** *Entalis herculea*, Kon.
*** *Allorisma perelegans*, W.
*** „ *pleuromyoides*, W.
* „ *dubium*, W.
* *Loripes atavus*, W.
* *Pleurophorus imbricatus*, Kon.
** „ *subovalis*, W.
* *Cleidophorus trapezoidalis*, W.
*** *Schizodus rotundatus*, Brown.
*** „ *pinguis*, W.
* „ *compressus*, W.
* *Myophoria cardissa*, W.
* *Septifer squama*, W.
* *Pseudomonotis kazanensis*, Vern.
* *Aviculopecten pseudoctenostreon*, W.
* „ *katwahiensis*, W.
* „ *squama*, W.
*** *Pecten prototextorius*, W.
* „ *subgranosus*, W.
*** *Dielasma breviplicatum*, W.
** *Dielasmina plicata*, W.
***** *Hemiptychina himalayensis*, Dav.
** „ *inflata*, W.
***** *Notothyris subvesicularis*, Dav.
***** „ *warthi*, W.
***** *Oldhamina decipiens*, Kon.
** *Rhynchonella wynnei*, W.
** *Camerophoria purdoni*, Dav.
***** *Spirigerella derbyi*, W.

*** *Spirigerella prælonga*, W.
** „ *hybrida*, W.
***** „ *minuta*, W.
** „ *media*, W.
** „ *ovoidalis*, W.
*** „ *fusiformis*, W.
*** *Athyris ambiguæformis*, W.
** „ *royssii*, Lév.
***** „ *sub-expansa*, W.
****** „ *capillata*, W.
*** „ cf. *pectinifera*, Sow.
***** *Spiriferina cristata*, Schloth.
* „ *vercherei*, W.
****** *Spirifer musakhelensis*, Dav.
* *Mariiniopsis inflata*, W.
* *Enteletes acuteplicatus*, W.
*** *Streptorhynchus pectiniformis*, Dav.
* *Derbyia regularis* var. *minor*, W.
****** „ *grandis*, W.
** „ *hemisphærica*, W.
** *Chonetes morahensis*, W.
* „ *avicula*, W.
* „ *trapezoidalis*, W.
* „ *bipartita*, W.
****** „ *squamulifera*, W.
** *Strophalosia varispina*, W.
****** *Chonetella nasuta*, W.
***** *Productus lineatus*, W.
** „ *subcostatus*, W.
****** „ *indicus*, W.
***** „ *gratiosus*, W.
***** „ *abichi*, W.
***** „ *purdoni*, Dav.
** „ *compressus*, W.
***** *Marginifera typica*, W.
***** *Richthofenia lawrenciana*, Kon.
** *Polypora ornata*, W. & P.
***** *Synocladia virgalacea*, Phill.
** *Thamniscus serialis*, W. & P.
** *Spirorbis helix*, King.
** *Cyathocrinus goliathus*, W.
*** *Hydriocrinus ? sp. ind.*
*** *Aræopora ramosa*, W. & W.

* *Michelinia abichi*, W.
***** *Geinitzella columnaris*, Schl.
***** *Stenopora ovata*, Lonsd.
* „ *nicholsoni*, W. & W.
*** „ *chætetiformis*, W. & W.
** *Lonsdaleia indica*, W. & W.
*** *Amplexus abichi*, W. & W.
***** *Hexagonella ramosa*, W. & W.
***** *Dybowskiella grandis*, W. & W.
** „ *expansa*, W. & W.
* *Steinmannia salinaria*, W. & W.
* *Fusulinella waageni*, Schwag.
* *Lingulina decipiens*, Schw.
*** *Margaritina schwageri*, Zitt.

The fauna of these beds is extremely rich in species; there are described and noted down here not less than 126; but as many as have been found up to the present, will, I am sure, yet be detected in the future, and chiefly of *cephalopoda* there will yet be a great harvest, if once the beds are systematically searched.

Of the many species, however, contained in these beds only few are exclusively restricted to this sub-division, while not more than 46 among the whole lot can be designated as such.

The beds here under consideration have about the same number (51) of species in common with those following lower in the series; and an equal number (55) extends from here to yet higher strata. Among the given numbers of species there are, however, 28 which extend through nearly all the strata of the productus-limestone, so that there remain only 23 which come from below, and have in the present sub-division their last representatives; whilst on the other hand there are 27 species which make their first appearance in the present sub-division and extend thence into higher beds.

If we take the entire character exhibited by this fauna into consideration, it must be confessed that though the species identical with permian ones are not very numerous, yet the whole character is decidedly permian. All the *Cephalopoda*, many of the *Gasteropoda*, and before all the *Pelecypoda* chiefly among the genera *Allorisma*, *Pleurophorus*, *Cleidophorus*, *Schizodus*, and *Pseudomonotis*, show thoroughly permian affinities. To these can be added as identical with permian forms the following species:—

Macrocheilus avellanoides, Kon.
Schizodus rotundatus, Brown.
Pseudomonotis kazanensis, Vern.
Spirigerella derbyi, W.
Athyris cf. *pectiniformis*, Sow.
„ sub *expansa*, W. = ? *Athyris royssiana*, Keys.

Spiriferina aristata, Schl.
Productus abichi, W.
Synocladia virgalacea, Phill.
Spirorbis helix, King.
Michelinia abichi, W. & W.
Geinitzella columnaris, Schl.
Amplexus abichi, W. & W.

Altogether 13 species; of these there are, however, not more than six representants of the typical permian fauna of Central Europe; the others are partly of Russian distribution, such as *Pseudomonotis kazanensis*, Vern., *Athyris royssiana*, Keys, &c., or they point to a permian territory, of which there has not yet been more detailed question in this work, and this is Djulfa on the Araxes in Armenia. This locality has been searched in detail and accurately described by Abich. He, however, considered the fauna contained in these strata as of lower carboniferous, mountain-limestone, age; and only later on it has been shown by Valerin *v.* Möller that the greater part of the species could be identified with permian forms. At the same locality the permian beds are followed by the lowest beds of the trias, as among the fossils collected there by Abich specimens of *Posidonomya clarai* were recognised by *v.* Mojsisovics.

Among the faunæ contained in the lower divisions of the Salt-range rocks, we have already several times had occasion to mention species identical with such from Djulfa. There were already *Macrocheilus avellanoides*, Kon., and *Prod. abichi*, W., present in the middle division of the middle productus-limestone and *Notothyris djulfensis*, Abich, in the upper division of the same group. Also predecessors of some Armenian species had to be mentioned by me in the lower productus-limestone, and these were *Marginifera ovalis*, W., of the group of *Marg. spinosocostata*, Abich, and *Marginifera transversa*, W., of the group of *Marg. helica*, Abich.

Now in the upper productus-limestone the species identical with such from Djulfa increase a litte but remain always yet very limited. To the forms already mentioned must now be added *Michelinia abichi*, W., and *Amplexus abichi*, W.

There are, however, in the Salt-range yet some analogous species, chiefly among the *cephalopoda*, which have their nearest allies in the deposits of Djulfa, and these are—

Salt-range.		Djulfa.
Nautilus transitorius, W.		*Nautilus tubercularis*, Abich.
„ *wynnei*, W.		„ *dorsoarmatus*, Ab.
„ *ophioneus*, W.	}	„ *convergens*, Ab.
„ *connectens*, W.	}	„ *parallelus*, Ab.
„ *convolutus*, W.	}	

Of these, three are species of the upper productus-limestone and two of the middle productus-limestone.

Above all this, the fact must yet be mentioned that at Djulfa numerous Ammonoid forms of *cephalopoda* have been found which exhibit rather conflicting characters. These cephalopoda are the following:—

Hungarites djulfensis, Abich.
Otoceras intermedium, Ab.
„ *tropitum*, Ab.
„ *trochoides*, Ab.
„ *pessoides*, Ab.
Gastrioceras abichianum, Möell.

Of these the genus *Hungarites* gives a very recent aspect to this cephalopod fauna; it is a genus that has been found up to the present exclusively in triassic beds, and the Armenian species is the only one that is quoted among palæozoic fossils. The genus *Otoceras* was created by Griesbach for certain Himalayan species which he considered as triassic at the time of their detection; but as they occur in nature together with palæozoic fossils, such as *Productus semireticulatus*, Mart., and *Spirifer rajah*, Salt., it is more probable that they may be yet of permian age and may characterise just the transitional beds between permian and trias. This is also the most probable position for the species of Djulfa.

A geologically very old type is represented by the genus *Gastrioceras*, and whilst the *Hungarites* gives a very recent aspect to the fauna, the genus *Gastrioceras* has a contrary effect. Species of the genus are common in the permo-carboniferous strata at Artinsk, as well as in the somewhat more recent deposits of Sicily, whilst they are absent in the Salt-range and here replaced by rather *Arcestes*-like forms.

All this makes it probable that a rather considerable stretch of time is represented by the deposits of Djulfa, and that though all the beds be permian, yet representatives of the lower as well as of the upper permian are there existing.

If we now consider the forms that are in common to the Salt-range as well as to Djulfa, we find that there are species of the middle as well as of the upper productus-limestone among them, but that those of the upper productus-limestone slightly predominate. For the middle productus-limestone, middle and upper divisions, we have found that its age very probably corresponds to that of the lower permian (rothliegende and somewhat higher) of Central Europe, and with regard to the upper productus-limestone the age must only now be fixed.

The relations that exist to the deposits at Djulfa make it already highly probable that also the upper productus-limestone must be of a permian age, and that as its bathrological position is above the middle productus-limestone, its equivalents must be looked for somewhere in the upper permian. However plausible such a conclusion may appear on a first glance it is difficult to prove it conclusively.

The permian of Europe contains but very few cosmopolitan species; and, before all, those air-chambered *cephalopoda*, which in most other formations furnish those species which can best be used for the comparison of deposits in far distant

countries, are nearly entirely absent. So we are restricted to the similarity or identity of a few forms of bivalves, *brachiopoda*, *bryozoa*, or corals, forms which have generally not a too great terrritory for their distribution. If we now, on the other hand, take into consideration the enormous distance of India from Central Europe, it must really be wondered at that some of the European species have had such an extended range of distribution as to reach even Indian territory.

It must be admitted that the species of the Salt-range which are identical or allied with those of Central Europe, all point to an age approximately equal to that of the magnesian limestone or zechstein of Europe. This, however, is not worth very much, for, regarding the enormous distance, they might easily hold in India a geological position slightly different from that occupied by them in Europe. We had to record already permian species in many of the lower divisions of the productus-limestone, and all these are found in Europe also in positions not different from those that are held by the species now under consideration. If thus the few permian species cannot well serve for an exact determination of the position the lower beds of the upper productus-limestone may hold within the permian system, we must get hold of other facts for such a determination, and there is no lack of such.

If the tertiary strata have been sub-divided into several formations according to the similarity their fossil contents exhibited with the fauna actually living in our seas; we may well follow a similar proceeding with the beds forming the connecting links between the palæozoic and mesozoic eras, and may say the nearer the single beds approach the mesozoic rock groups in time, the more frequently mesozoic types ought to appear in them if otherwise the deposition of the beds has been a regular one.

In Europe this has not been the case. The permian beds were there deposited in more or less isolated slowly-drying up basins, which gave rise to the accumulation at certain places of enormous quantities of rock salt, and were afterwards replaced by beds deposited probably in fresh or brackish water and devoid of marine fossil remains.

In India the case was quite different. The Salt-range strata were deposited along the shore of a large open sea, which communicated freely with other marine basins in all directions; and thus forms could become admixed with the constituents of the fauna then living there which could not enter the isolated basins then existing in Europe. This is the reason that we find in the beds here under consideration a number of species of mollusca, which one has been accustomed up to the present to observe only in mesozoic strata by the side of a number of most characteristic permian species, which, however, occur in India as well as in Russia already in earlier strata than in Central Europe.

Already in the middle productus-limestone, such mesozoic types occur in limited numbers; as has been shown on a former page: but the more we ascend in the series of Salt-range rocks, the more frequently do they appear, until in the topmost beds both types very nearly equal each other in numbers.

The mesozoic types existing in the lower and middle divisions of the upper productus-limestone are the following:—

Arcestes (?) *priscus*, W.
Xenodiscus carbonarius, W.
„ *plicatus*, W.
Nautilus latissimus, W.
„ *convolutus*, W.
Phasianella arenicola, W.
Margarita prisca, W.
Loripes atavus, W.
Myophoria cardissa, W.
Septifer squama, W.
Pecten prototextorius, W.
Hemiptychina inflata, W.
Oldhamina decipiens, Kon.

Whilst in the middle productus-limestone the number of species exhibiting mesozoic affinities were not more than 5, we find in the present sub-division already 13 species of this sort, and among them affinities of the gravest description.

Before all, the cephalopoda are very remarkable. Cephalopod faunas of a permo-carboniferous or permian age have been described recently from Artinsk and from Sicily. With both these faunas the one from the Salt-range here under consideration has only the genera *Medlicottia* and *Popanoceras* in common; whilst the genera *Xenodiscus* and *Arcestes* (?) are absent in Europe and the Ural, the former occurring however frequently in triassic beds of Siberia and India, whilst the latter is altogether of triassic distribution. Considerations of this kind may have led Mr. Griesbach to pronounce even all the productus-limestone as of triassic age.

The cephalopod faunas of Sicily and the Ural are however very probably not of the same geological age, the former being probably considerably more recent than the latter. According to Karpinsky's exceedingly interesting monograph the following genera occur at Artinsk:—

Pronorites, 2 sp.
Parapronorites, 3 sp.
Medlicottia, 4 sp.
Propinacoceras, 1 sp.
Gastrioceras, 5 sp.
Paralegoceras, 1 sp.
Agathiceras, 3 sp.
Popanoceras, 12 sp.
Thalassoceras, 1 sp.
Paraceltites, (?)
Goniatites, 2 sp. (?)

For many of these forms Karpinsky gives at the same time the information necessary as to their relations to the truly carboniferous species of *cephalopoda* occurring in the Ural.

If we compare this fauna with the one occurring in the *Fusulina* limestones of Sicily, we find that the latter is far richer in species and genera. It will also be useful to quote here for comparison's sake the genera occurring in the latter deposits. The genera are the following:—

Parapronorites, 1 sp.
Sicanites, 2 sp.
Medlicottia, 5 sp.
Propinacoceras, 3 sp.
Darneilites, 1 sp.
Gastrioceras, 4 sp.
Glyphioceras, 2 sp.
Agathiceras, 3 sp.
Adrianites, 12 sp.
Doryceras, 2 sp.
Clynolobus, 1 sp.
Popanoceras, 4 sp.
Stacheoceras, 12 sp.
Waagenoceras, 3 sp.
Hyattoceras, 3 sp.
Thalassoceras, 4 sp.
Paraceltites, 4 sp.
Brancoceras, 1 sp.

From this list we see that though the greater part of the genera is identical in the Ural and in Sicily, yet there are some differences which are very suggestive for the determination of the relative age of the two Ammonite faunas.

For instance, in the Ural the genus *Pronorites*, Mojs., which comprises very characteristic lower carboniferous types, is present, whilst it is absent in Sicily and so on; and one can in general say that in the Ural the truly *Goniatitic* forms predominate, whilst the truly *Ammonitic* types are represented there only by the genus *Popanoceras*, Hyatt. In Sicily, on the contrary, the truly *Ammonitic* types are much more numerously represented, and there are, besides *Popanoceras*, the genera *Stacheoceras*, *Waagenoceras*, and *Hyattoceras* which belong to them. Besides this, the latter two genera show a much more progressed development of their sutural lines than *Popanoceras*.

In such a manner we come to the conclusion that the yellowish limestones of Sicily hold a geological position considerably higher in the general sequence than the sandstones of Artinsk. Now, these latter as far as is known up to the present occupy the highest place in that division of rocks which is generally com-

prised under the name of "Permocarboniferous," and we have seen that the Artinsk stage is in its geological position about equal to the lower productus-limestone and the lowest beds of the middle productus-limestone in the Salt-range.

If now the limestones of Sicily are considerably higher in their position, they must be true permian, and cannot certainly be lower than the lower permian or "rothliegende."

If we now compare, on the other hand, the Cephalopod-fauna of Sicily with that of the upper productus-limestone of the Salt-range, we see that the latter exhibits again a far more progressed state of development than the former. The genus *Topanoceras* is here present again, as at Artinsk and in Sicily. So is the genus *Medlicottia*; but at the side of these are other forms which have either not been found anywhere else, as *Arcestes* (?) *priscus*, W., but approach already very near to the triassic forms, or which are directly generically identical with triassic fossils, as *Xenodiscus*, which genus has its chief development in triassic strata only.

To these must yet be added the genus *Cyclolobus*. Though it does not occur just in the beds here under consideration, it may as well be discussed here, as there is no distinct indication that a diligent search will not reveal specimens of this genus also in these slightly lower strata. The group of forms to which *Cyclolobus* belongs is well represented in Sicily by the fossils that have been named *Waagenoceras* by Gemmellaro, but is entirely absent at Artinsk. The relations between *Cyclolobus* and *Waagenoceras* are very close; and it has even been advocated by Mojsisovics to consider the two as identical. My own opinion in the matter is, however, much more in accordance with the one expressed by Professor Gemmellaro, and I think every one who compares the drawings on Pl. A. of Gemmellaro's "Appendice" that has been published in the meantime, will be convinced that the sutural lines of *Cyclolobus* and *Waagenoceras* show such a different degreeof development that the two must be considered as generically different. *Cyclolobus* is by far the more progressed one; and according to all the observations that have been made with regard to the development of the *Cephalopoda* in time, one should think that it must be geologically much more recent than the species of *Waagenoceras* of Sicily.

Thus all we can gather with regard to the Cephalopod fauna of the upper productus-limestone leads us to the conclusion that it more nearly approaches the triassic Cephalopod fauna in its general habitus than any of the other palæozoic Cephalopod fauna that have been described up to the present, with the sole exception, perhaps, of Djulfa, where the genera *Hungarites* and *Otoceras* give also a more or less triassic habitus to the fauna. These latter, however, are there associated with numerous specimens of *Gastrioceras* which, on their part, again point to very ancient affinities; so that the conclusions that may be drawn must necessarily become much more vague, as the evidence is much more conflicting than in the Salt-range. Here all the observations with regard to the Cephalopoda point in one and the same direction, *viz.* that the beds which contain these species must be situated very high in the palæozoic series, approaching in their position more or less the triassic system.

If we now put this conclusion in accordance with the number of permian species which have been found in the present sub-division, and with the other mesozoic types occurring there, among which is already a *Myophoria*, we arrive at the final result, that the lower and middle beds of the upper productus-limestone cannot be lower in their geological position, even if we neglect the genus *Cyclolobus*, which in fact has not yet been found except in the upper sub-division, than the middle permian of Europe; that is to say, about on the level of the lower half of the magnesian limestone of England, or the lowest part of the zechstein proper in Germany. An exact correlation is naturally, at such distances and under such different modes of deposition, out of the question.

We may thus, on the whole, fairly accept for the lower and middle beds of the upper productus-limestone, an age somewhat more recent and more approximated to the lowest divisions of the triassic system than the "Rothliegende" of Germany.

The other relations that may present themselves are implied in this determination, and it will be possible to recur to this point in the discussion of the fauna of the Cephalopoda beds.

β. Cephalopoda Beds.

It has been stated above that it is very doubtful whether these beds should really be distinguished as a proper stage from the lower and middle beds of the same group.

The materials for the distinction of a proper stage are almost too limited, as I myself have only been able to distinguish these beds at a few localities. Nevertheless, I think it will be interesting to a certain degree also to the larger public to learn in detail what species have been found directly associated with those *Cephalopoda* my detection of which has been met with much doubt in the beginning. There were chiefly two localities at which the species enumerated in the following list were collected, and these were Jabi and Chidru, as at these places alone it was possible to find out the special bed in which the cephalopoda occurred. At other localities the specimens of ammonite-like cephalopoda were found loose on the ground, though in the direct vicinity of the bed in which they occurred, yet in such a manner that it was not possible to state with all possible certainty from what special inch of rock they had come.

At the two localities mentioned, the chief layer with cephalopoda was found to be situated a little above the middle of the upper productus-limestone: and the fossils, which were found yet above these beds and below the sandstones forming the topmost beds, were yet added to the contents of the cephalopoda layers; as I soon was convinced that it was not possible to avoid an admixture of the contents of these higher strata, as they were rolling down in numbers from above. The time for digging for the fossils of a special bed was not at my disposal then, and I had to content myself with the materials which presented themselves to me above ground.

The species which I collected in this manner with, and above, the cephalopoda which I have first described in the Memoirs, Geological Survey of India, Vol. IX, are the following:—

** *Helodopsis elongata*, W.[1]
* *Cyclolobus oldhami*, W.
** *Xenodiscus carbonarius*, W.
** „ *plicatus*, W.
* *Medlicottia primas*, W.
*** *Euomphalus pusillus*, W.
*** *Holopella trimorpha*, W.
** *Macrocheilus avellanoides*, Kon.
** *Bellerophon triangularis*, W.
** *** *Entalis herculea*, Kon.
** *** *Allorisma perelegans*, W.
** „ *pleuromyoides*, W.
* „ *sp. indet.*
* *Palanatina indica*, W.
* *Modiola transparens*, W.
* *Atomodesma indicum*, W.
* *Pseudomonotis deplanata*, W.
** *Oxytoma atavum*, W.
* *Aviculopecten jabiensis*, W.
** *Pecten prototextorius*, W.
* *Dielasma acutangalum*, W.
** „ *breviplicatum*, W.
** *Hemiptychina himalayensis*, Dav.
** *Notothyris subvesicularis*, W.
** „ *warthi*, W.
** *Oldhamina decipiens*, Kon.
** *Uncinulus theobaldi*, W.
** „ *jabiensis*, W.
* „ *posterus*, W.
* *Camerophoria globulina*, Phill.
** „ *superstes*, Vern.
** *Spirigerella derbyi*, W.
** „ *prælonga*, W.
** „ *minuta*, W.
** „ *grandis*, W.
** „ *fusiformis*, W.
** *Athyris ambiguæformis*, W.

[1] In this list, * signifies species peculiar to the sub-division, ** species coming below, *** species extending above, ** *** species coming from below and extending above.

* *Athyris grossula*, W.
** *** „ *subexpansa*, W.
** „ *capillata*, W.
** „ cf. *pectinifera*, Sow.
** *Eumetria grandicosta*, Dav.
** *Spiriferina cristata*, Schl.
** „ *multiplicata*, Son.
*** „ *ornata*, W.
** *Spirifer musakhelensis*, Dav.
* *Martinia chidruensis*, W.
** *Streptorhynchus pectiniformis*, Dav.
** *Derbyia grandis*, W.
* „ *altestriata*, W.
* „ *plicatella*, W.
* *Orthothetes semiplanus*, W.
** *Chonetes squamulifera*, W.
* „ *grandicosta*, W.
* „ *æquicosta*, W.
* *Strophalosia indica*, W.
** *Chonetella nasuta*, W.
** *Productus lineatus*, W.
** „ *cora*, Orb.
* „ *aratus*, W.
** „ *indicus*, W.
** „ *gratiosus*, W.
** „ *asperulus*, W.
** „ *abichi*, W.
* „ *serialis*, W.
* „ *cylindricus*, W.
* „ *opuntia*, W.
** „ *tumidus*, W.
* „ *mytiloides*, W.
** *Marginifera typica*, W.
*** „ *ornata*, W.
** *Richthofenia lawrenciana*, Kon.
** *Cardinocrania indica*, W.
** *Fenestella jabiensis*, W.
** *Polypora koninckiana*, W. and P.
* „ *biarmica*, Keys.
* *Phyllopora jabiensis*, W. and P.
* „ *cribellum*, Kon.
** *Synocladia virgalacea*, Phill.
** *Poteriocrinus sp. ind.*

** *Arœopora ramosa*, W. and W.
* *Pachypora curvata*, W. and W.
* „ *jabiensis*, W. and W.
* *Michelinia placenta*, W. and W.
** *Geinitzella columnaris*, Schl.
** *Stenopora ovata*, Lonsd.
** „ *chætetiformis*, W. and W.
** *Amplexus abichi*, W. and W.
** *Hexagonella ramosa*, W. and W.
** *Dybowskiella grandis*, W. and W.

There are altogether 90 species, of which, however, not more than 30 are peculiar to the present sub-division. The greater part of the forms comes from the lower sub-divisions, and there are not less than 56 species which are in common with the sub-division here under consideration, and those following lower in the series. The most remarkable fact, however, is, that nearly all these species terminate in the present sub-division, and that only three of them extend into the next higher strata. The connection of the fauna of the cephalopoda beds with that of the latter is also in other respects very small, as there are not more than four species which commence here and extend into the topmost beds.

Of species which have been found in other countries in permian strata there are again a certain number present. These are—

Macrocheilus avellanoides, Kon.
Camerophoria globulina, Phill.
„ *superstes*, Vern.
Spirigerella derbyi, W.
Athyris subexpansa, W. [=*Ath. royssiana* (Keys.) Tehern.]
„ cf. *pectinifera*, Sow.
Spiriferina cristata, Schl.
„ *multiplicata*, Sow.
Productus abichi, W.
„ *tumidus*, W. [= ? *Prod. cancrini* (Vern.) Tehern.]
Polypora biarmica, Keys.
Synocladia virgalacea, Phill.
Geinitzella columnaris, Schl.
Amplexus abichi, W.

Of these 7, that is just half the number, occur in the zechstein of Central Europe, some are characteristic of the permian of Russia, and the remainder appear again in the permian of Djulfa.

If we had thus reasons to consider the preceding sub-division as to a certain extent equivalent to the zechstein, and thus have accepted the permian species occurring in that sub-division as leading in this respect, this will also have to be accepted on yet better grounds for the present sub-division. The European permian

species are here more numerous by two, the *Ceratite*-like cephalopoda occur here as well as in the lower beds, and to these the genus *Cyclolobus* is yet added, which, a has been shown above, shows a far more progressed state of development than its relations in other countries.

Though there are thus many reasons why these beds should be considered as representing in a homotaxical way the upper permian of Europe, yet it cannot be denied that the fauna has a "habitus" about it which one is generally not wont to see in permian deposits. Already the great many species of *Productus* is something very extraordinary, and among these are species like *Prod. lineatus*, W. and *Prod. cora*, Orb., which are not only characteristic of the lower divisions of the productus-limestone, but occur in other parts of the world in the true coal-measures. In opposition to this, there are, however, again other species like *Productus opuntia*, W. which are very nearly related to permian species, and probably only vicarying (*sic*; ? representative) forms or geographical varieties. Among these may also be counted the *Strophalosia indica*, W., which has originally been described as *Strophalosia morrisiana*, King, by Davidson.

In the whole list, however, there is no species which would absolutely demand consideration of these beds as more ancient than the zechstein, and the differences that are exhibited by this fauna from the fauna of the permian of Europe only prove that the European fauna is an impoverished one, like that of the Caspian Sea of the present day; impoverished by the circumstance that the European sea basins of that time had but little intercommunication with the oceans of other parts of the world. These conditions are also proved by the enormous accumulations of rock-salt and gypsum in these strata, which could not have been formed if a quite open communication with a great ocean had existed. So we cannot consider the European permian fauna either as typical or as normal; and from the beginning it appeared probable that if a permian fauna could be detected anywhere that has flourished under normal conditions, this would contain a much greater variety of species and genera than we find in these beds in Europe.

Thus the great number of manifold forms of which the fauna of the upper productus-limestone has been composed, as far as we have taken it into consideration up to the present, cannot be considered as an argument against the upper permian age of these strata.

The affinity, on the other hand, that is exhibited by a number of species occurring in these beds to mesozoic forms goes far to strengthen the opinion just expressed that the cephalopoda bed also should be taken as of a upper permian age, and in part homotaxically equivalent to what has been called "zechstein" in Germany or magnesian limestone in England.

8. Topmost beds of the Upper Productus-Limestone.

This is again a sub-division of very great geological importance.

In the sequence of rock groups of the Salt-range, it occupies the last place

within the Upper Palæozoic series, and in other respects it is a group which is poorly conspicuous and likely to be very easily overlooked. Nevertheless, its fossil contents are of the utmost interest, and give occasion for very important conclusions.

Above the yellow or brownish, sometimes also greyish, dolomitic sandy beds of the preceding sub-division, there follow a few layers of a grey paper-colored sandstone, mostly very soft, and containing large concretionary lumps of the same sandy nature, but of much greater hardness, which are protruding from the rock where disintegration by weathering has gone on.

Fossils are not everywhere present in this rock, but if they occur, they are in great numbers. They are then attached to the surface of the concretions just mentioned and are mostly of a calcareous nature, only rarely are they silicified. Sometimes also the whole concretions are filled with them.

The sections in this region are, however, very variable, and it will be necessary to quote some of them in order to give a clear idea of the composition of this subdivision.

A typical section of these beds was measured near Chidru, and it runs as follows :—

Ceratite formation (part of).		5. Greenish-grey soft marls with many calcareous concretions and numbers of *ceratites*, causing the formation of a little valley	60-80 feet.
		4. Very hard thinly bedded limestones, ringing under the hammer, of a light-grey colour, containing very numerous *ceratites*	3-5 „
Upper Productus-limestone.	Topmost beds.	3. Soft grey sandstones without fossils	6 „
		2. Grey marls	4-5 „
		1. Soft light-yellow sandstones with many concretions, filled with fossils	6 „
	Lower divisions.	0. Brownish-yellow sandy dolomitic beds in great thickness.	

In this section the position of some of the beds is somewhat questionable. These are the beds numbered two and three, which are without fossils, and which according to their petrographical condition agree more with the lower beds No. 1, and according to their colour are more in accordance with the superimposed strata. From the facts, however, ascertained at other places, it appears more probable that they should be counted with the productus-limestone.

At other places near Chidru these beds, Nos. 2 and 3, are either absent or altogether represented by yellow sandstone, as is evident from the section at Chidru represented on page 208 of the present work.

Another section of these beds was observed near Virgal. In leaving the village round the tank there, one finds first, in ascending the mountain side, enormous

accumulations of débris, all formed of fragments of the siliceous limestones of the middle productus-limestone. Large colonies of silicified corals are disseminated among them. In reaching the live rock one sees that it is absolutely filled with corals, and in consequence the stratification becomes very indistinct. The whole mountain, up to its very summit, is composed of these coral limestones. Between the coral beds there are irregular layers of a softer nature, composed nearly entirely of fragments of crinoids. Only, after having passed that whole mountain, does one reach the brownish sandy dolomitic beds of which the upper productus-limestone is composed. In order to find a continuation of the section, one must leave the path and descend into the khud. There one finds on the top of the upper productus-limestone a thick bed of light-grey sandstone, with large loaf-like or irregular concretions in which the fossils are accumulated. This bed is about 10 feet thick and has furnished the following species:—*Nautilus latissimus*, W., *Margarita prisca*, W., *Pleurotomaria punjabica*, W., *Pleur. sequens*, W., *Murchisonia conjungens*, W., *Bucania angustifasciata*, W., *Bucan. integra*, W., *Bucan. ornatissima*, W., *Euphemus apertus*, W., *Antale, sp. ind.*, *Sphæriola grandæva*, W., *Lucina progenitrix*, W., *Gouldia primæva*, W., *Pleurophorus complanatus*, W., *Pleur. acuteplicatus*, W., *Cleidophorus striatulus*, W., *Myophoria præcox*, W., *Myoph. subelegans*, W., *Nucula ventricosa*, Hall., *Pecten præcox*, W., *Euchondria subpusilla*, W., *Streptorhynchus distortus*, W., *Productus purdoni*, Dav., *Rhombopora polyporata*, W., *Margaritina schwageri*, Zitt.

Above this bed, follow black carbonaceous sandy and strongly micaceous marls, with traces of coal, but no distinct plant-remains. Their thickness is about 20 feet.

These are followed, again, by grey sandstones without fossils, about 10 to 15 feet thick; when they are immediately succeeded by the hard grey, thinly bedded ceratite limestones, the lowest member of the ceratite formation.

At the base of the limestones there are, first, a few irregular discontinuous limestone slabs covered with the remains of *Gyrolepis* or something like it: and I feel sure that, in spending some time there, entire fishes could be found. Only then the continuous regular limestone layers commence, filled with *ceratites*, which are, however, generally badly preserved.

These limestones are about 8 to 10 feet thick, and are followed by the whole ceratite formation, as far as it is developed in this neighbourhood.

This section can be easily brought into accordance with the one from Chidru quoted before. The beds above the fossiliferous sandstones and below the ceratite limestones are again unfossiliferous, but the carbonaceous condition of the shales and the general occurrence of sandstones show that a change of conditions had taken place in comparison with those prevailing during the deposition of the middle, and the remainder of the upper, productus-limestone.

There are, however, yet further sections which display this fact still more clearly.

Such a section is, for instance, at Amb. There follow, above the brownish sandy dolomitic beds of the lower divisions of the upper productus-limestone, white sandstones with several intercalations of black coaly shales, the whole about 25 feet thick. The sandstones contain more or less numerous concretions, which are generally crowded with fossils; among them *Nautilus multituberculatus*, W., *Pleurotomaria durga*, W., *Spengleria vetusta*, W., *Eucharis grandæva*, W., *Lucina progenitrix*, W., *Astarte ambiensis*, W., *Aricula chidruensis*, W., *Athyris subexpansa*, W., *Spirifer ambiensis*, W., *Marginifera ornata*, W., &c.

Above these beds the section becomes indistinct for a short distance, but some grey sandstones seem to intervene, and then follow the thinly bedded hard grey ceratite limestones.

In this section there appear already, between the single layers of the fossiliferous sandstones, carbonaceous intercalations; a variety of rock which was never observed by me in the productus-limestone except in the lowest division. Their intercalation here with the fossiliferous sandstone seems, however, to prove, that the beds up to the base of the ceratite limestones should yet be assigned to the palæozoic strata, as here apparently the carbonaceous beds of the Amb section and the fossiliferous sandstones blend together.

The most abnormal section, however, in this region presented itself to me at Siran-ki-dok. This section, which interests us here particularly, comprises all the beds of the variegated series, the bivalve limestones, and the ceratite beds down to the permian strata, runs as follows in that part:

No. 35. Ceratite marls, greenish marls, with some harder beds and some *ceratites* . . . . . 30 feet.
„ 36. Bed of conglomerate of a brownish colour . . . . 1½ feet.
„ 37. Brown rusty dolomites, very hard . . . . . 6 feet.
„ 38. Light-yellowish sandstones, of great thickness, with *Bellerophon jonesianus*, Kon. *Sprigerella derbyi*, W., &c.

The lowest beds evidently represent the lower and middle divisions of the upper productus-limestone, to which also the next following band of rusty dolomites, which we have already frequently met in the productus-limestone at lower positions, must be added.

Of the top beds of the upper productus-limestone there is not a trace existing. These have evidently been destroyed by denudation.

The brown conglomerates No. 36 must, most probably, be taken as belonging to the *ceratite* formation and forming perhaps the equivalents of the thinly bedded ceratite limestones of other sections; as some 60 feet higher in the same section there occurs again a very similar conglomerate in the upper region of the ceratite formation.

The ceratite marls, No. 35, are a very constant member of the ceratite formation throughout the Salt-range. They follow everywhere regularly above the ceratite limestones, and form thus the second sub-division of the formation.

So we see that in some places abrasion took place in the Salt-range, at others coaly deposits have been formed; and all this proves beyond doubt that great changes have taken place in the conditions of deposition as compared with those that prevailed during the formation of the next lower sub-divisions.

These changes also find their expression in the contents of those strata which have furnished fossils up to the present. The fauna is composed of the following species:[1]—

* *Petalorhynchus indicus*, W.
* *Hystracanthus giganteus*, W.
* *Thaumatacanthus blanfordi*, W.
* *Nautilus multituberculatus*, W.
** „ *latissimus*, W.
** *Euomphalus pusillus*, W.
* *Holopella trimorpha*, W.
* *Neritomopsis minuta*, W.
* *Phasianella arenicola*, W.
* *Margarita prisca*, W.
** *Pleurotomaria punjabica*, W.
** „ *sequens*, W.
* „ *durga*, W.
** *Murchisonia conjungens*, W.
** *Bellerophon jonesianus*, Kon.
* *Bucania angustifasciata*, W.
** „ *integra*, W.
* „ *ornatissima*, W.
* *Warthia polita*, W.
* *Euphemus apertus*, W.
** „ *lævis*, W.
** *Entalis herculea*, Kon.
* *Antale, sp. indet.*
* *Spengleria vetusta*, W.
* *Eucharis grandæva*, W.
** *Allorisma perelegans*, W.
* *Sphæriola grandæva*, W.
* *Lucina progenitrix*, W.
* „ *bombifrons*, W.
* *Astarte ambiensis*, W.
* *Gouldia primæva*, W.
* *Pleurophorus complanatus*, W.
* „ *acuteplicatus*, W.

[1] In this list * signifies species peculiar to the sub-division, ** species coming from below.

* *Cleidophorus striatulus*, W.
** *Schizodus rotundatus*, Brown.
** „ *pinguis*, W.
* „ *dubiiformis*, W.
* *Myophoria præcox*, W.
* „ *subelegans*, W.
* *Nuculina subacuta*, W.
* *Nucula ventricosa*, Hall.
** „ *trivialis*, Eichw.
* *Dolabra corbina*, W.
* *Lithodomina typa*, W.
* „ *abbreviata*, W.
* *Lithodomus atavus*, W.
* *Mytilus patriarchalis*, W.
* *Pseudomonotis radialis*, Phill.
* „ *inversa*, W.
* *Avicula chidruensis*, W.
* *Lima footei*, W.
* *Aviculopecten subexoticus*, W.
* *Pecten præcox*, W.
* *Euchondria subpusilla*, W.
** *Athyris subexpansa*, W.
** *Spiriferina ornata*, W.
* *Spirifer ambiensis*, W.
* *Streptorhynehus distortus*, W.
** *Productus purdoni*, Dav.
** *Marginifera ornata*, W.
* *Rhombopora polyporata*, W.
* *Hydriocrinus*? *sp. ind.*
* *Margaritina schwageri*, Zitt.

There are altogether 63 species, of which 17 are identical with forms occurring already in the preceding divisions of the productus-limestone, whilst 46 are peculiar to the sub-division here under consideration. As far as is known to me up to the present, there is not a single species which would extend into the triassic beds of the ceratite formation.

The most striking character of this fauna consists in the rareness of *Brachiopoda*, which up to this have composed generally about half of the entire fauna of the preceding sub-divisions; and next to this is the great proportion of peculiar species which deserves our special interest.

Of species identical with those of the permian system of other countries are the following :—

Schizodus rotundatus, Brown.
Nucula trivialis, Eichw.
Pseudomonotis radialis, Phill.
Athyris subexpansa, W.

Besides these identical species, there are yet about six more which exhibit a decidedly permian habitus, though they are specifically not identifiable with permian forms. In the previous sub-divisions we had generally to record about 12 to 14 species identical with those of the permian of other countries, besides a far greater proportion of analogous forms. From all this it appears that the affinity of the beds here under consideration with the permian is on a decline, whilst the relations to mesozoic strata have increased enormously.

If we pass in review the species peculiar to the present sub-division we find that there are 24 species with palæozoic and 22 with mesozoic affinities.

Such a proportion of palæozoic to mesozoic forms has not existed in the lower sub-divisions; and taking this into consideration, together with the great physical changes that have taken place, as we have seen, with the commencement of the present sub-division, we are led to suppose that a new order of things is initiated by the beds now under consideration. These beds can barely any more be properly called permian; they rather seem to form a transitional stage, a sort of passage beds between the palæozoics and the mesozoics.

Such passage beds have already for a long time been suspected to exist at Djulfa; whilst in Europe the Platten-dolomite and the Red Marls above these forms also a kind of transition between the permian and the Bunt sandstone, though fossils are absent in both.

At Djulfa the existence of the genera *Otoceras* and *Hungarites* chiefly gave rise to the suspicion that such transitional layers existed, but of these genera not a trace is to be found in the Salt-range. There are, however, other places in India where the genus *Otoceras* has been found, and these must be taken into consideration presently.

In 1880 Mr. Griesbach published a paper in the Records, Geological Survey of India, Vol. XIII, in which he has not only defined the genus *Otoceras*, but where he also compares the beds he observed in the Himalayas, in the Niti and Milam areas, with those of the Salt-range. He gives a very detailed section of the beds there, with indications of the fossil species contained in each; but it seems that the determinations given are only rather approximate, as the distribution as indicated, though in general being well in accordance with the facts observed in the Salt-range, yet in detail so far deviates, that it appears probable that many of the species quoted by Griesbach are only representative forms, and not absolutely specifically identical with the Salt-range species, as described by Koninck.

Part of Griesbach's section runs as follows :—

		Ft.	In.
1. Werfen beds.	9. Shales with limestone 1″ towards the top, with *Otoceras woodwardi*, n. s.	5	0
	8. Limestone	0	2
	7. Shales	0	5½
	6. Limestone with—	0	3
	Xenodiscus gangeticus, DeKon.		
	„ *buchianus*, „		
Salt-range zone of *Ptychites lawrencianus*, DeKon. *Xenodiscus demissus.* „ *gangeticus.*	5. Variegated papery shales	0	6
	4. Limestone with—	0	4
	Avicula venetiana, Hau.		
	Myophoria ovata, Br.		
	Posidonomya angusta, Hau.		
	Otoceras woodwardi, n.s.		
	Xenodiscus demissus, Opp.		
	„ *gangeticus*, DeKon.		
	3. Friable papery shales with a parting of limestone (1″) with—	0	9
	Otoceras woodwardi, n.s.		
	2. Dark-grey limestone with shaly layers with— .	0	5
	Posidonomya angusta, Hau.		
	Gervillia mytiloides, Schlot.		
	Modiola triquetra, Seeb.		
	Myophoria ovata, Gdfss.		
	Avicula venetiana, Hau.		
	Bellerophon, sp.		
	Nautilus brahmanicus, n.s.		
	Otoceras woodwardi, n.s.		
	„ „ var. *undulatum*, n.s.		
	Ptychites lawrencianus, DeKon.		
	Ophiceras medium, n.s.		
	„ *himalayense*, n.s.		
	„ *tibeticum*, n.s.		
	„ *densitesta*, Waag., var.		
b. Campiler beds (Alps).	*Xenodiscus gangeticus*, DeKon.		
	„ *buchianus*, „		
	„ *demissus*, Opp.		
	Trachyceras gibbosum, n.s.		
a. Seiss beds (Alps) Salt-range productus beds.	1. Dark carbonaceous, crumbling shales, micaceous, weathering in reddish and deep-brown tints, giving it a variegated appearance, with a few thin beds of hard grey limestone. The general character of these shales is the same as of all the intercalated beds of shales of the beds above	127½	
	It yielded—		
	Monotis claræ, Emmr.		
	Productus latirostratus, Howse, var.		
	Arcestes sp.		

This section is very interesting, though the correlations proposed are open to grave doubts for a part at least.

Mr. Griesbach is probably quite correct in bringing the dark carbonaceous shales (Kuling shales of Stoliczka) into connection with the *Productus* beds of the Salt-range, but to correlate these with the Seiss beds of the Alps is certainly erroneous. This has been admitted also by Griesbach, in his recent publication on the subject in the Records, Vol. XXII, page 166.

The *Otoceras* beds, following above these shales in a thickness of about 8 feet, are now considered by Griesbach as a transitional stage between the palæozoics and mesozoics, and I perfectly concur with him in this respect. There can, however, be no question of correlating these beds with the "zone of *Ptychites lawrencianus*, Kon., *Xenodiscus demissus*, Opp., and *Xen. gangeticus*, Kon." of the Salt-range.

First, it is yet very doubtful whether *Xenodiscus demissus*, Opp., occurs at all in the Salt-range, and then the other two species do not occur in the same beds there.

Xenodiscus (*?*) *gangeticus* is found in the lowest beds of the hard trias limestones, the lowest beds of the Trias existing in the Salt-range; and *Ptychites* (?) *lawrencianus* is characteristic of the ceratite marls which follow very much higher in the section.

The form that is quoted under the latter name in the Himalaya is probably a vicarying (? representative) one, occurring at a lower geological horizon.

From the assemblage of species, however, quoted by Griesbach from his *Otaceras* stage, it appears neither probable that these beds should be placed on a level with the lowest ceratite limestones of the Salt-range, the fauna of the two deposits being too little in accordance, as I shall have occasion to show in describing the fauna of the ceratite beds, nor can they be compared to the fossiliferous top-beds of the upper productus-limestone. In the *Otoceras* beds the mesozoic types seem to predominate over the palæozoic ones, and thus it appears probable that they are somewhat more recent than the mentioned strata of the productus-limestone.

We have seen that in the Salt-range, at most places, some unfossiliferous beds intervene between the fossiliferous top-beds and the triassic limestones, and it is not impossible that these may represent the *Otoceras* beds in the Salt-range. The absence here of the genus *Otoceras* would then also be explained; as in the Himalaya also it is restricted to a very little extended series of rocks, and is entirely absent in higher strata.

So the passage beds between the palæozoics and mesozoics would apparently be made up of two horizons; one lower, represented by the fossiliferous top-beds of the productus-limestones, and one upper, represented by the *Otoceras* beds.

Such passage beds have not yet been observed in any other country; and thus my task of comparing the single fauna of the different palæozoic rock-groups of the Salt-range with those of other countries has come to an end, and I can pass to the discussion of the general features resulting from the special comparisons.

Conclusion.

In passing in review all that has been said with regard to the palæozoic strata of the Salt-range, we find that several chief results are prominent among the others and appear as of overwhelming importance.

The first of these is the determination with all possible certainty of Cambrian beds in the Salt-range; and the bearing this discovery has, considering the facts existing in China, on the determination of the Vindhians of Peninsular India as probably also of a Cambrian age. I myself had failed, when in the Salt-range, to detect the definitive proofs for such a determination; and Mr. Wynne had also no other proofs for his "Silurian" age of these beds than the reputed existence of *Obolus* in them, a determination that has proved to be erroneous.

But though I thus was to a certain degree at fault with regard to this question, yet the definitive solution of it was due to my intervention, as upon my personal instigation Dr. Warth commenced his search for trilobites in these beds.[1]

I may be allowed to state here these facts, as I have been very strongly abused for not having detected all the truth at once.

The area which is occupied on the earth's surface by Cambrian beds has been very considerably increased by this discovery, and though Cambrian beds could not be identified with certainty in the Himalayas, yet it is highly probable that they exist there too. The difficulties of identification in that region arise chiefly from the circumstance that the beds are generally all strongly metamorphosed.

The second most important fact is the detection of a great unconformity existing in the Salt-range above the cambrian beds. Also, with regard to this detection, I myself am rather innocent. From the sections published on some of the foregoing pages it will be seen that I myself had seen at certain places something like; but in the face of Mr. Wynne's emphatical denial of any unconformity, I myself distrusted these few local observations, and laid no stress whatever on them. It is the merit of Mr. R. D. Oldham to have first furnished conclusive proofs as to the existence of this unconformity, which afterwards were confirmed by King, Middlemiss and others.

Above this unconformity there follow beds, containing numbers of glacially striated pebbles, which have been formed beyond doubt under the influence of ice action. As in the Talchir beds of Peninsular India, similar features had been known to exist long since, and these also rest unconformably on the Vindhians. It was nothing but natural to suspect a corresponding age for the two. There was, however, not much gained by such a correlation, as neither the boulder-beds of the Salt-range nor the Talchirs could definitively be determined as to their real age; some taking them to be triassic, others palæozoic; though the latter determination was, according to the parallelisation with the beds of the Salt-range, the more probable one.

[1] It is to be regretted that Dr. Waagen still adopts a *hedging* course. He clearly worked out his previous views according to the evidence before him: so did Wynne with regard to the occurrence of Obolus: but, up to this point, the personal instigation of Dr. Warth was to renew the search for fossils, not for trilobites. The discovery of trilobites was quite new and indeed unexpected.—Ed.

And now we come to the third most important fact detected in the Salt-range, and this is the discovery of an Australian carboniferous fauna in the lower speckled sandstone to which the boulder beds belong. The specimens were detected by Dr. Warth in nodules or pebbles in the boulder bed itself, and their Australian affinity was first determined by myself. Afterwards, however, also the few fossils which had been collected by Mr. Wynne in the greenish sandstones above the boulder beds were recognised by me as Australian forms.

Now, after this discovery, it was possible to determine the exact age of these beds with regard to the general standard of formations; and with this also to settle definitively the age of the talchirs.

The fourth most important fact is the recognisation of the productus-limestone as of a permian age. By Mr. Davidson's determinations of the few brachiopoda, the conviction had taken place that nothing, or nearly nothing, but carboniferous beds were exposed in the Salt-range; and I had in the beginning to struggle very much against this conviction, which was supported by an authority like that of Mr. Davidson.

The permian fauna thus recognised is a perfectly peculiar one, and probably represents the normal type of a permian fauna; whilst the fauna detected in Europe in these beds is an impoverished one, like that of the Caspian Sea of the present day. The most peculiar features of this fauna are, on the one hand, the great many carboniferous types contained in it, and, on the other, the admixture of a certain percentage of mesozoic types. This leads us to the fifth most important fact detected in the Salt-range, namely the existence of passage beds there between the palæozoics and the mesozoics. Many mesozoic types make their first appearance already at far lower horizons than had been suspected before the fauna of the Salt-range had been worked out. In higher strata these types augment considerably, whilst the palæozoic ones are at the same time slowly reduced, until in the topmost beds of the productus-limestone both are about equal in number. If the next higher following strata, which are probably the equivalents of the *Otoceras* beds in the Himalayas, were fossiliferous, the proportion would probably be reversed, until in the *Ceratite* beds the palæozoic types are nearly altogether excluded.

Thus, the greatest break that is known to exist between single formations,—the break between palæozoics and mesozoics, a break that exists nearly everywhere in the whole world—is here bridged over: and the proof is furnished that also at the limit between the two large eras, the continuous development of the organic world has not been interrupted.

Of these fundamental facts, only the smaller part has been made out exclusively by myself; and it is chiefly due to the zealous collaboration of many of my former colleagues and friends that all the fundamental points relating to the geology of the Salt-range have now been cleared up.

It is my duty to express to them here all my most sincere thanks for this collaboration.

The facts enumerated up to this by me are all such as are chiefly of importance

for the geology of the Salt-range itself: there are, however, many more which are of importance also for geological science in general.

There is, before all, one point which is of the utmost importance in this respect; and this is the bearing the geology of the Salt-range has on the general classification of the upper palæozoic rocks.

If we look up Prof. Gümbel's Handbook, the most recent and most complete general account of our knowledge with regard to the science of geology, we find that in the lower palæozoic formations it is tolerably well known how the single systems, as the Cambrian, Silurian, &c., are developed in different countries; and this greater exactitude of our knowledge finds expression in the tabular views reproduced in Gümbel's most valuable publication.

As soon, however, as the learned author enters the carboniferous period, the tabular views which constituted up to then one of the most valuable parts of the book disappear, and are only resumed when the author enters the discussion of the Trias. Nothing could show more clearly how rudimentary our knowledge of the formations composing the upper palæozoic series has been up to the present than this. Also, in Prof. Neumayr's, "Erdgeschichte" this insufficiency of our knowledge of these formations comes clearly to light.

The reasons for this circumstance are two-fold, and have been partly pointed out already by my last-named most deeply regretted friend. The greatest impediment to a classification of the rocks belonging to the upper palæozoic formations rests on the circumstances that heteromesic deposits are of such frequent occurrence here and that the view formerly held, that all the marine beds must be geologically older than those formed under the influence of fresh water, because in Central Europe such a sequence had been first observed, was overcome only with the greatest difficulty, and after long and continued controversies.

Another cause, to which already Prof. Neumayr has drawn attention, consists in the mode of treatment the different marine fauna have experienced in the hands of different men of science.

Through M. Barrande's fundamental publications on the Silurian strata of Bohemia, there has been introduced in the description of the fauna of the lower palæozoic deposits a very narrow circumscription of the single species; so that, by a comparison with his plates, it was easy to find out whether one had to deal with absolutely identical, or with slightly deviating forms; and thus also his followers in science were involuntarily led to circumscribe their species more narrowly. With such narrowly circumscribed species, however, it becomes much more easy to distinguish the subsequent stages of development of a fauna, and thus the distinction and comparison of different horizons in distant countries can be placed on a much sounder footing than would otherwise be the case.

In the carboniferous formation, on the contrary, M. de Koninck's fundamental works introduced an interpretation of species of such an extent as did not exist in any other formation; and even characters which would have led to the distinction of genera in other cases were entirely neglected if only an external similarity

between the single forms existed. Thus, the myth had originated that in the carboniferous formation the geographical and geological range of species was far more extended than in any other period of the earth's history.

Certainly there are in the carboniferous formation, chiefly among the *Brachiopoda*, ubiquitous species, as in other rock systems; but, as certainly also, they are not developed to such an extent as has been accepted up to the present by most authors treating of the subject. For instance, the Australian carboniferous deposits contain a great number of forms which partly, even generically, do not agree with European forms, but which nevertheless have been identified specifically with European species by M. de Koninck.

It was, therefore, absolutely unavoidable to desert this system of identification, which must needs lead to erroneous conclusions; and I have endeavoured to apply to carboniferous forms a similar standard of distinction of species as is used in other formations. The American authors had already done in this respect a good deal beforehand; but also here, in the upper coal-measures, a very wide geological range of the single species is generally accepted.

The results of my proceeding already begin to show themselves; and, in the Ural there have been identified already a number of species distinguished by me in the Salt-range, holding there a quite peculiar geological position. Would it have been possible to recognise this horizon in the Ural as existing also in the Salt-range if I had described all the forms as *Productus semireticulatus*, and so on?

I may have made many mistakes in special cases; but the principle is sound, and one must recur to a more narrow circumscription of species if one would ever arrive at a thorough classification of horizons within the period, and at a comparison of these horizons in distant countries.

In the Salt-range, however, only the upper half of the rock-groups of which the upper palæozoic series is composed is developed. For the lower half the Russian authors, who have already made so excellent a commencement with their publications, will have to do the palæontology.

In this endeavour they must only not lose sight of the consideration that "species," if we consider the entire development of the organic world, is absolutely a fiction which has no real existence, but a fiction that is absolutely necessary for our comprehension of the mode of development; and I have distinguished this modification of species in one of my former publications under the designation of "mutation." If we consider, however, only a single division of a larger formation, "species" becomes a reality, as at the time of the deposition of that division, the form which just occurs there is distinct from all the others occurring in the same bed. Therefore, if we anyhow can distinguish a form in a certain bed from those above or below, we must lay greater stress on the distinctive characters than on the connecting ones; as only in such a way shall we arrive at a clear idea of the fauna existing at a certain given time, and of its grade of development in comparison with those above and below.

Now, after the developmental connection of the organic world has been proved

beyond doubt in by far the majority of cases, it is no longer our first duty to prove such a connection; but, before all, we must now lay stress on the dissimilarities of the succeeding forms in different layers. Palæontology, as well as Geology, will profit by such a proceeding.

The Salt-range, which has now unveiled to us a quite new fauna, is of great importance for the classification of the deposits of the upper palæozoic formations.

There is, before all, the occurrence of an Australian fauna in the beds immediately succeeding the great unconformity, a very peculiar feature. These beds had already been brought into a parallel with the Australian deposits by Mr. R. D. Oldham on account of the occurrence of traces of glacial action in both, whilst the evidence of the fossils was not accepted by him, as he considered them as occurring in a secondary position. Only quite recently conclusive proofs have been produced that the fossils identical with Australian species were in their original position, and that the age of these beds could be determined by them.

Nevertheless, the occurrence of these beds in the Salt-range is such that only the identity of them with the corresponding Australian beds can be deduced, but their exact age, with regard to the general standard of formations, cannot be exactly fixed. The only clue for the solution of this question rests in the circumstance that its position is rather far below the beds which we have recognised to be of a permian age.

For the exact determination of the age of these beds we must turn to Australia. The comparison of the lower speckled sandstone with the Australian deposits has been discussed in detail in the description of the lower speckled sandstone in the preceding pages. We have seen there that in horizons holding a lower geological position than the beds showing traces of glacial action at most places, deposits exist which contain a truly carboniferous flora; and the same is the case in South Africa; only that there the type of the flora is a decidedly upper carboniferous one.

Thus it becomes probable that the whole set of rocks exposed in the Salt-range, above the great unconformity, is more recent than the true productive coal-measures of Europe and elsewhere.

This is not quite in accordance with what I formerly maintained, that the beds following below the middle productus-limestone were about of the age of the coal-measures. This opinion was correct, as long as the Russian publications on the Ural had not appeared; now, after these works have been published, a more correct view in the matter can be taken.

By these studies it had been shown that the carboniferous was not followed directly by the permian; but that an extended group of rocks intervened which could not be well attributed to either of them, and for which the old name of permo-carboniferous was applied by the Russian authors.

The Artinsk strata belong to this group of rocks.

We have seen, in the course of the present work, that these beds are represented in the Salt-range by the upper speckled sandstone and the lowest division of the middle productus-limestone. Thus we see that the lowest beds of the speckled sandstone are more recent than the productive coal-measures; and the highest beds

are on a level with the Artinsk strata, which are immediately below the lowest permian.

So we come to the conclusion that the speckled sandstone forms a group of rocks by itself which corresponds in a general way to the permo-carboniferous of the Russian authors.

This group can be very conveniently divided into three stages ; the lowest, comprising the boulder beds, may best receive the name of Talchir group. For the middle one it is difficult to find a name. Its chief development, as far as is known up to the present, is apparently also to be found in the southern hemisphere; and thus the name Newcastle beds, from Newcastle in New South Wales, would perhaps be the most appropriate, but as there are so many Newcastles, this name cannot do. At the same time, it is not improbable that all that has been called "Newcastle beds" does not form only a single stage, but comprises a large extent of rocks. Thus, I am led to call it in a provisional way Karharbari stage. The next higher stage takes very naturally its name from Artinsk in the Ural, and may be called the Artinsk stage.

Much more difficult is it to decide what place the whole permo-carboniferous group may have to occupy in the general sequence. I am inclined to follow in this respect Gümbel's indications. He distinguishes in the Rhenish regions, above the true coal-measures, a group of rocks which he includes in the permian system, but which is more ancient than anything that has been called permian up to this. The fossil contents are only plant-remains and vertebrates. In the lowest of these series of rocks, the "Unter Cuseler Schichten," permian plants begin to make their first appearance; in the "Obere Cuseler Schichten" they begin to become more frequent; and in the "Lebacher Schichten" they are already well represented, as is the case in the Artinsk sandstones. I am inclined to consider this complex of beds as the equivalent of the marine permo-carboniferous, and to include these, as well as the true permo-carboniferous in the permian system, though this system has got there a quite other composition than was formerly attributed to it. My reasons for beginning a new system with the permo-carboniferous strata are: first, the glacial deposits at the base, second, the appearance of a mesozoic flora in these beds in the southern area, and third, the first appearance here of large numbers of *Ammonitidæ*. Thus, the permo-carboniferous would form the lowest rock group of the permian system.

My former correlation of some of these beds with parts of the American marine coal-measures nevertheless stands firm. It has been shown by me, on some of the preceding pages of this work, that the marine coal-measures of North America are in part even to be placed on a parallel with the lower permian of Europe. The greatest part of them, however, corresponds to the permo-carboniferous as just defined, and in fact the term was first created for and applied to those beds.

The higher following groups and stages give no difficulty; they may be seen from the accompanying tabular view, which I have drawn up in order to elucidate more clearly than has been possible in the text, the relations that exist between the Salt-range rocks and the deposits known to exist in other countries.

Tabular View showing the relations of the Salt-range Upper-Palæozoic strata to the deposits of other countries.

Epoch.	Systems.	Groups.	Stages.	North America.	NORTHERN TYPE. WESTERN EUROPE. Northern parts.	NORTHERN TYPE. WESTERN EUROPE. Mediterranean region.	NORTHERN TYPE. Russia and the Ural Mountains.	NORTHERN TYPE. China and some other scattered Asiatic localities.	NORTHERN TYPE. Himalaya.	SALT-RANGE.	SOUTHERN TYPE. Peninsular India.	SOUTHERN TYPE. South Africa.	SOUTHERN TYPE. AUSTRALIA. Queensland.	SOUTHERN TYPE. AUSTRALIA. New South-Wales.	SOUTHERN TYPE. AUSTRALIA. Victoria.	SOUTHERN TYPE. AUSTRALIA. Tasmania.	SOUTHERN TYPE. Brazil.
	Triassic.			Red triassic sandstones of Connecticut, etc. Marine beds of the western parts.	Bunt sandstone.	Werfen beds, with *Posidonomya clarai.*	Variegated sandstones and marls.	Werfen beds, with *Posidon. clarai* of Djulfa.	Werfen beds, with *Posidon. clarai.*	Ceratite limestone, the lowest division of the ceratite formation.	Panchet Group.	*Beaufort* beds. This very extensive series must probably be sub-divided in the future, and it will then very likely be found that the beds containing a Damuda flora hold a lower position than the beds with *Dicynodonts*, exactly as it is in India.	? Mesozoic coal-seams with *Thinfeldia odontopteroides.*	? Hawksbury beds. ? ? Traces of glacial action.	?	Upper coal measures.	Triassic sandstones.
Permian system.		Magnesian Limestone.	Passage beds.	Limestones and shales, with *Pseudomonotis hawni* (—*speluncaria*) of Kansas, red gypsum beds of Texas.	Red shales. Platten Dolomit. (Salt of Stassfurt.)			*Otoceras* beds of *Djulfa.*	*Otoceras* beds of Niti.	Unfossiliferous sandstones and shales.							
			Gypsum stage.		Gypsum and Rauchwacke, with few fossils.	*Bellerophon limestone*, with *Bellerophon, Stachella, Spirifer vultur, Bakwellia ceratophaga*, etc.	*Permian* of the *Gouv. Perm.* variegated beds of marl and sandstone, with intercalated beds of limestone, dolomite, gypsum and rock-salt, with the well-known Permian fauna.			Upper Productus-limestone. Top beds of the Upper Productus-limestone or Chidru beds.	*Ranigunj* Group.			? ? Hawksbury beds (part of) ?			?
			Zechstein.	Bryozoan reefs, with *Fenestella retiformis, Synocladia virgalacea*, etc. Dark limestones, with *Productus horridus, Strophalosia goldfussi*, etc.		*Röthi-Dolomit* of Switzerland.		Permian beds of *Djulfa* with: *Prod. horridus, Prod. hemisphæricus, Rhynchonella geinitziana, Athyris subtilita, Strept. pelargonatus, Gastrioceras abichianum*, etc.		Cephalopoda beds of the Upper Productus-limestone or: Jabi beds. Middle and Lower divisions of the Upper Productus-limestone or: Khund Ghat beds.					Upper marine beds of the *Mersey* coal-field with *Spirifer cardiomorpha, Pachydomus, Sanguinolites*, etc.	
		Rothliegendes.	Weisliegendes and marl slate.	Red sandstones and shales of Texas, with many remains of Vertebrates, *Amphibia* and *Reptilia*, and *Goniatites bayloreus. Hyattoceras cumensis, Medlicottia copei* and *Popanocerus walcotti.*	*Kupferschiefer* (*Marl slate*) with fishes, reptiles, and plants *Nöggerathia, Voltzia, Ullmannia*, etc. *Zechstein Conglomerate* with *Strophalosia lepiayi*, etc.	*Grôden Sandstone*, coarse red sandstone and shales with *Ullmannia brouni, Bayera, Voltzia, Callipteris, Calamites*, etc. *Verrucano* conglomerate and porphyries of *Botzen.*		Middle Productus-limestone. Upper division of the Middle Productus-limestone or: Kalabagh beds.	Kuling shales.	Damuda series.*	*Raniganj* Group.	Ironstone shales.					?
			Gypsum stage.	Red and grey sandstones and shales of *Nebraska-City*, with *Solemya biarmica, Schizodus truncatus, Sch. rotundatus, Cleidophorus costatus, Pseud. radialis, Ps. speluncaria, Product. cancrini, Polypora biarmica*, etc.	Red sandstones, shales and conglomerates with *traces of ice-action* in England. Porphyries of frequent occurrence. Plants: *Calamites Lepidodendron, Stigmaria, Sigillaria, Walchia, Voltzia, Araucarites*, etc.	Fusulina limestone of Sicily with numerous Cephalopoda.	*Permian* of the *Gouv. Kostroma*, limestones, dolomites and gypsum with *Astarte permocarbonica, Athyris roysiana, Productus canerini, Aulosteges wangenheimi*, etc.	?		Middle division of the Middle Productus-limestone or: Virgal beds. Lower division of the Middle Productus-limestone or: Katta beds.							
		Permo-carboniferous.	Artinsk stage.	Marine beds of Platters Mouth, with *Fusulina*, &c., and beds below (up to about 2,000 feet in thickness) down to the Productive coal-measures. Upper Barren-measures, with some coal-seams and *Odontopteris obtusiloba, Callipteris conferta, Alethopteris gigas*, etc.	*Lebacher Schichten* grey and red shales and sandstones with fishes and amphibians and *Calamites major, Cyclopteris, Callipteris, Cyatheites, Sphenopteris, Alethopteris*, etc.	Fusuline limestone of Poutafel, with numerous marine fossils.	Limestones and dolomites. *Sandstones of Artinsk* with numerous cephalopoda and *Productus spiralis, Marginifera typica, Spirifer marcoui, Spirif. fasciger, Spirif. alatus, Product. cora*, etc.	Cephalopoda beds of *Darwaz in Buchara* with *Pronorites praepermicus, Propinacocer, darwasi, Agathiceras uralicum, Popanoceras romanowskyi.*	White limestone of the *Milam Pass* with *Hemiptych. himalayensis, Notothyris subvesiculars, Athyris royssii, Spirif.* cf. *glaber, Prod. semireticulatus, Lytonia*, etc.	Lower Productus-limestone or Upper Speckled Sandstone: Amb beds.							
			Karharbari stage.		*Obere Cuseler Schichten* grey and red beds with some coal-seams, *Calamites, Lepidodendron Sigillaria*, — *Cordaites, Callipteris conferta. Odontopteris obtusiloba, Alethopt. nervosa, Cyatheites, Neuropteris, Sphenopteris, Walchia*, etc.		Apparently *absent* in the *Ural*, perhaps represented in the North (*Timan, Novaja Semlia*, etc.)	Marine beds of *Loping* in China.		Speckled Sandstone. Middle Speckled Sandstone.	*Karharbari* beds.		*Kimberley shales* and sandstones with *Gangamopteris cyclopteroides* var. *attenuata, Nöggerathiopsis hislopi.*		*Bacchus Marsh* sandstone with *Gangamopteris.*	Lower marine beds of the Mersey coal-field with *Stenopora, Spirifer, Productus, Strophalosia, Terebratula, Allorisma, Sanguinolites, Eurydesma, Pachydomus, Bellerophon, Conularia*, etc.	Shales and quartzites with *Lepidodendron*, and a glacial boulder-bed at some horizon.
			Talchir stage.		*Untere Cuseler Schichten* grey sandstones and shales. First appearance of *Calamites gigas, Callipteris conferta, Lonchopteris rugosa*, associated with many Carboniferous types. Fishes: *Acanthodes.*			? Coal-seams of *Loping*? *Unconformity.*	? Marine beds of *Timor*?	Lower Speckled Sandstone. *a.* Brown or greenish sandstone with *Eurydesma.* *b.* Boulder-beds with *Conularia.* *Strong traces of glacial action.*	*Talchir* sandstone and shales. *Talchir* boulder-bed. *Strong traces of glacial action.*		*Ecca shales* with *Glossopteris angustifolia.* *Ecca or Dwyka* boulder-beds. *Strong traces of glacial action.*	? Absent.		*Bacchus Marsh* boulder-beds. *Strong traces of glacial action.*		
Carboniferous system.	Coal-measures.	Coal-measures.	Ardwick stage.	Upper Productive Coal-Measures, without *Lepidodendron.*	*Othweiler Schichten* (Schwadowitzer and Radowenzer Schichten). Calamarien und Farn Stufe.	Partly marine Fusulina limestones. Partly slates and sandstones with plant-remains of Upper carboniferous species (*Stang Alpe*, etc.)	Upper carboniferous limestone of Moscow, Tastuba, Traoslawka, etc. with *Fusulina verneulli, Schwagerina, Spiriferina saranae, Product. villersi, Prod. cora, Enteletes, Spirif. mosquensis, Sp. striatus, Pronorites, Agathiceras*, etc.	Productive coal-measures of *China.*	Fusulina limestones of *Sumatra* and *Japan.*	? Dark flaggy limestones of *Spiti.*	Absent. The Boulder-beds resting unconformably on Cambrian strata.	Absent. The Boulder-beds resting unconformably on the Vindhyans, which are probably of a Cambrian age.	Beds of *Tulbagh*, Lower Albany, Tete on the Zambesi, etc., with *Sigillaria, Stigmaria, Asterophyllites equisetiformis, Pecopteris listi, Alethopteris lonchitica, Lepidodendron crenatum, Calamites*, etc.	Star river series.	Sandstones with *Productus cora.*	? ? ? Lower marine beds.	?	Absent.	Sandstones with an Upper carboniferous flora.
		Gannister series.	Pennant series.	Lower Barren Measures, with limestone seams, with *Productus semireticulatus, Spirifer cameratus, Athyris subtilita.*	*Saarbrücker Schichten* (Schatzlarer Schichten). Sigillarien Stufe.												
				Lower Productive Coal Measures, with *Lepidodendron* and *Sigillaria.*													
	Millstone grit.			*Pottsville conglomerata* (Pennsylvania.)	Millstone grit (St. Ingbert Schichten.)	Culm (Upper). *Ostraner* and *Waldenburger Schichten*, with many coal-seams and *Archæocalamites radiatus, Lepidodendron Veltheimianum, Sphenopt. elegans*, etc.	Middle carboniferous limestone with *Productus scabriculus, semireticulatus, pustulosus, costatus, Athyris subtilita, ambigua, Dielas, sacculus*, etc.	?	*Muth quartzites.*			? *Zuurberg* sandstone with *Lepidodendron.*	Star river series.	Sandstone of *Bohuntungen* on the Drummond range with *Calamites radiatus, Lepidodendron veltheimianum.**	Beds of *Stroud, Port Stephen*, etc. with *Calamites radiatus, Lepidodendron veltheimianum*, etc. Marine beds with fossils (not yet described).	*Avon* sandstone with *Lepidodendron australe.*	Absent.	?
		Mountain limestone.	Visé stage.	Chester Group. St. Louis Group.	*Yordale* series.	Culm (Lower). Slates, sandstones and some limestones with *Cardiopteris frondosa, Archæopteris dissecta, Posidonomya bronni, Goniatites, Euphemus urii* etc.	*Gailthaler Schiefer*, dark coloured slates, sandstones, and coarse conglomerates with *Product giganteus, Naut. subsulcatus, Prod. punctatus, Spirif. bisulcatus*, etc. More slates and conglomerates below.	Marine limestones with Lower Carboniferous fossils of *China.*	Red crinoidal limestone.								
			Waulsort stage.	Keokuk Group (Archimedes limestone).	Maine limestone.		Lower Carboniferous limestone with *Productus giganteus, Pr. semireticulatus Pr. striatus, Athyr. expansa, Martinia glabra, Dielasm, hastatum, Bellerophon, Phillipsia globiceps*, etc.					? *Table Mountain* sandstone.					
			Tournai stage.	Burlington Group (Encrinital limestone).	Lower limestone shales.				Earthy dark-grey limestones.								
	Devonian.		Passage beds.	? Kinderhook Group.	*Pilton beds.*	?	*Malewka Murajewna* stage.	?	?			?	Mount Wyatt beds with *Lepidodendron nothum.*	Beds of *Goonoo-Goonoo* with *Lepidodendron nothum.*	*Iguana Creek* beds.	Shales of *Fingal.*	?

* This position of the Damuda-series seems to me the most probable one for the moment. It cannot, however, be considered as definitively settled, being in contradiction to Dr. Feistmantel's views. The definitive solution of the question can only be expected from the detection of plant-remains in the Salt-range, a thing that is not absolutely hopeless either in the coaly shales below the Ceratite limestone, or in similar beds of the Lower Productus-limestone. The only determinable plant-remains, encountered in the Salt-range up to this, have been found in the Variegated series, and are Rajmahal species.

The most remarkable fact appearing on a first glance at this tabular view is the medium position the Salt-range holds between two large areas of deposition, in which the single sub-divisions are developed according to different types. For the one I use the term "Northern type," for the other "Southern type."

The first is characterised by the circumstance that workable coal-seams are chiefly situated in the lower half of the upper palæozoic formation, or the carboniferous system of rocks; that the plants associated with the coal-seams, and also much higher up, show a perfectly palæozoic character; that traces of ice-action are very rare; and that the marine fauna, where present, shows a character of its own, quite peculiar to this type of development.

The second or southern type, on the contrary, is characterised by the rich and numerous workable coal-seams being congregated in the upper half of the upper palæozoic formations, that is to say in the permian system. The plants that accompany them are of a mesozoic type, and palæozoic plant forms are only to be met with in lower geological positions, generally not associated with coal-seams. Traces of ice-action are of very frequent occurrence and often of an overwhelming development. The marine fauna, where existing, shows a quite peculiar habitus, being chiefly characterised by the occurrence of large bivalves and deviating forms of brachiopoda. Volcanic eruptions during the time of deposition of the upper palæozoic formations are more frequent in the region of the southern than in that of the northern type.

The northern type is chiefly developed in the northern hemisphere, where, starting from the Salt-range, we find its occurrence in the Himalaya, China, Russia, Western Europe, the Arctic regions and North America. There are, however, also some places where this type extends far towards the south, as in Sumatra and in Timor.

The southern type is for the greater part restricted to the southern hemisphere. We find it developed in Australia and South Africa in a typical manner. North of the equator it is to be found in Peninsular India and extending perhaps into Afghanistan. Brazil belongs for a part probably also to this type; but it is to a certain extent also transitional to the northern type, as the northern, and not the southern, marine fauna extends yet to this country. I have left it standing in the tabular view in a provisional way under the heading "Southern type."

This southern type was up to the present a great riddle to geologists, as well as to palæontologists, because the intermixture in the beds belonging to this type of palæozoic marine fossils with plants exhibiting a mesozoic habitus was extremely conflicting. Those among the observers who laid the greater stress on the plants invariably considered these beds as mesozoic; whilst others, who studied only the marine animals, like M. de Koninck, came to the conclusion that these strata were true mountain limestone. Never have opinions upon the same beds more strongly deviated from each other than here; and it would never havebeen possible to reconcile these opinions and arrive at the bottom of the thing had not the Salt-range now furnished the clue for the solution of the question. Now, there is no help any more

but to consider those plants exhibiting mesozoic affinities, which occur in the very lowest divisions of the permian system, and above which an enormous amount of different stages, yet all belonging to the palæozoic area, as palæozoic, notwithstanding their mesozoic habitus. At the same time it was also possible to show from the finds of the Salt-range that these beds did not belong to the mountain limestones, but were of a very much more recent age.

In one of my former publications I endeavoured to show that the very strange fact of mesozoic plant types in palæozoic strata was probably due to a change of climate, by which the palæozoic forms had been prematurely extinguished and a more hardy set of mesozoic plants occupied the place of the former. The proofs of such a change seemed for me to rest on the frequent occurrence of glacial deposits in the area occupied by the southern type. This opinion has, however, been strongly opposed from different sides, though, it seems to me, without sound arguments. If we look at the facts recorded on the tabular view, it will be very easily perceived that the palæozoic plant types are everywhere present below the beds in which traces of ice-action have been recorded, and that they everywhere disappear above those beds, mesozoic types taking their places.

This change comes on at the base of the permo-carboniferous rock-group in the southern region, and in the group of the Rothliegende in the northern region in accordance with the different placement of the glacial deposits; so that in the latter region the palæozoic floras reach up much higher in the sequence of rocks than in the southern.

That the intense cold indicated by the existence of these glacial deposits, which show in some cases a more intense development even than most of the deposits of the quarternary glacial period, should not have even effected so much influence as to change the development and distribution of the single flora, is barely possible.

Where no glacial deposits intervene the palæozoic forms of plants extend to the upper half of the permian system. Yet, far more close than with regard to the plants is the connection of the carboniferous and permian systems in respect of the marine fossils. As long as the Salt-range fauna had not been made known; beds which did not exhibit the impoverished character of the Central European permian deposits were not admitted in the permian formation; and though Prof. Geinitz himself had recognised the permian character of certain beds in North America, this view was not generally accepted, as the fauna of these beds showed too many connections with the fauna of the coal-measures below. The break that one supposed must needs exist between carboniferous and permian was here absent, and thus the beds considered by Mr. Geinitz as permian could not be of that age.

Slowly, however, the number of places at which transitional fauna between carboniferous and permian were detected augmented considerably; and one soon fell into the other extreme of doubting even the validity of the permian altogether, and tried to merge it into the carboniferous. Things developed so quickly in this respect that Prof. Geinitz considered it necessary to send round an appeal to the scientific world not to abolish the permian system.

The result of all this has been that the term 'carboniferous' was applied in very different senses. Sometimes the true carboniferous, that always had been comprised under the name, was meant by it; sometimes only the coal-measures, as has been advocated by Prof. Gümbel; while again the name was extended to comprise part of, or even the entire, permian system.

That the result of this was a great confusion is nothing but natural.

Now, one can see somewhat more clearly in the matter. The fixing of a distinct transitional permo-carboniferous group has brought the two systems into a still closer connection; but at the same time it was brought to light that the two systems, carboniferous as well as permian, are of about equal geological value, and that it would not do to merge one into the other, as this would give a far too extended complex of rocks, perfectly unwieldy for treatment by the geologist in the field. Thus, the two systems must be kept separate. At the same time, however, it is very desirable that the intimate connection between the two systems should also find an expression in the nomenclature. This can only be done by comprising the two as a group of a higher order under one name. The term 'carboniferous' cannot here be used again, as with this the old confusion would again be sanctioned; and yet the most characteristic feature of the two systems is the frequent occurrence of coal-seams. Thus, I venture to propose for the whole, for the Carboniferous and Permian systems together, the name of 'Anthracolithic Epoch.'

That the palæozoic rocks in general had to be divided into two large series, of which the lower was comprised under the name of 'Gornwacken Gebirge,' whilst the upper formed the 'Upper Palæozoics' had been recognised already by Neumayr; and he gave expression to his views in his "Erdgeschichte," that true treasure of geological literature. My 'Anthracolithic Epoch' corresponds now to Neumayr's 'Upper Palæozoics.'

This is all I have to say with regard to the palæozoic rock-groups of the Salt-range, and those formations that are in connection with similar deposits in other countries.

Only one point has yet occurred to me in working out the present results; and this is, that I remarked that the names I have applied to the different sub-divisions of the productus-limestone are very unpractical. Who could, in working out complicated questions of a geological nature, repeatedly use terms like "Middle division of the Middle Productus-limestone," etc.? This seems barely possible. I therefore propose here to give local names to the single sub-divisions for simplicity's sake, and have chosen for this purpose the following designations:—

Topmost beds of the Upper Productus-limestone . .	= Chidru beds.
Cephalopoda bed „ „ „ . .	= Jabi beds.
Lower and middle divisions of the Upper Productus-limestone	= Khund Ghat beds.
Upper division of the Middle Productus-limestone . .	= Kálabágh beds.
Middle division „ „ „ . .	= Virgal beds.
Lower division „ „ „ . .	= Katta beds.
Lower Productus-limestone or Upper Speckled-sandstone .	= Amb beds.

The localities which are selected as names for the beds are always those at which the single beds are most characteristically developed.

With this I can take leave of the reader. I have endeavoured to make this work as useful as possible to Indian geology, as well as to geological science in general. Whether I have succeeded I do not know. It may be that I may have committed many an error; and in the first attempt to solve questions which seemed inaccessible up to then this can barely be avoided, but I have done the best I could to remain on safe ground. The errors will be corrected in time, and I shall be very glad if they are. I only make one appeal to the public; this is, that such corrections may be always made with that kindness and consideration as is the general custom in such matters.

PLATE I.

CAMBRIAN.

Fig. 1. CONOCEPHALITES WARTHI, Waagen, n. sp., p. 94. Specimen from the upper region of the *Neobolus* beds of Chél hill; 1*a* the head, natural size; 1*b* the same enlarged.

" 2. Free check of a *Trilobite*, perhaps of the preceding species; from the same beds and locality as fig. 1. 2*a* natural size; 2*b* the same, enlarged.

" 3? OLENUS INDICUS, Waagen, n. sp., p. 97.
Specimen from the topmost region of the *Neobolus* beds of Kussak; 3*a* fragment of the head, natural size; 3*b* the same, enlarged.

Figs. 4 and 5. Posterior species of free cheeks of *Trilobites* from the upper region of the *Neobolus* beds of Chél hill. Fig. 4*a* natural size; 4*b* the same, enlarged. Fig. 5*a* natural size, 5*b*, *c*, *d*, enlarged; external and internal views and transversal section.

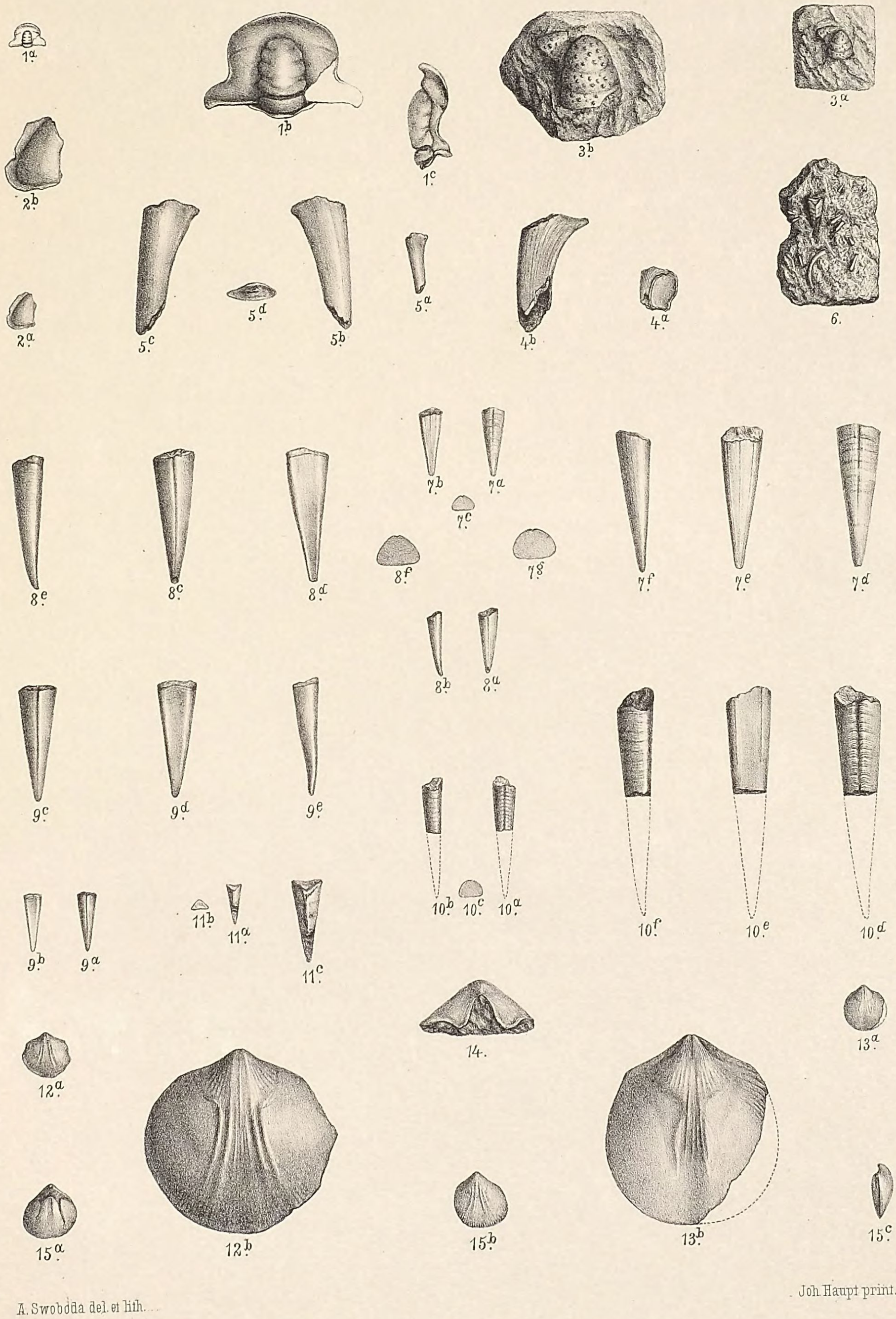
Fig. 6. Piece of sandstone with fragments of (?) *Trilobites* species from the topmost region of the *Neobolus* beds of Kussak.

Figs. 7—9. HYOLITHES WYNNEI, Waagen, p. 99.
Three different specimens from the upper region of the *Neobolus* beds of Chél hill, different views, natural size and enlarged.

Fig. 10. HYOLITHES WYNNEI, Waagen, var.
From the same beds and locality as the preceding; 10*a*, *b*, *c*, natural size; 10*d*, *e*, *f*, the same, enlarged.

" 11. HYOLITHES KUSSAKENSIS, Waagen, n. sp., p. 101.
Specimen taken from the piece of sandstone represented in fig. 6; 11*a*, *b*, natural size, 11*c* the same, enlarged.

Figs. 12—15. ORTHIS WARTHI, Waagen, n. sp., p. 102.
Three specimens from the upper region of the *Neobolus* beds of Chél hill. Fig. 12*a*, large valve, natural size; *fig.* 12*b*, the same, enlarged. Fig. 13*a*, smaller valve, natural size; fig. 13*b*, the same, enlarged. Fig. 14, area and deltidial fissure of the larger valve, enlarged. Fig. 15*a*, *b*, *c*, specimen with both valves, dorsal, ventral, and lateral aspects, all natural size. (For enlarged figures of the same specimen see the following plate).



A. Swoboda del. et lith.

Joh. Haupt print.

PLATE II.

CAMBRIAN.

Fig. 1. ORTHIS WARTHI, Waagen, n. sp., p. 102.
Enlarged figures of the specimen represented in fig. 15 of the preceding plate.

Fig. 2. ORTHIS WARTHI, Waagen, n. sp., p. 102.
Very young specimen from the upper region of the *Neobolus* beds of Chél hill fig. 2 *a*, *b*, *c*, enlarged; fig. 2 *d*, *e*, natural size.

Figs. 3—4. LAKHMINA LINGULOIDES, Waagen, sp.
From the lower region of the *Neobolus* beds of Kiura, both valves, natural size and enlarged.

Figs. 5—9. NEOBOLUS WARTHI, Waagen.
Specimens from the lower region of the *Neobolus* beds of Kiura, both valves, natural size and enlarged.

Figs. 10—11. NEOBOLUS WYNNEI, Waagen.
Specimens from the lower region of the *Neobolus* beds of Kiura (fig. 10) and Intana (fig. 11) both valves, natural size and enlarged.

Figs. 12—14. SCHIZOPHOLIS RUGOSA, Waagen.
Specimens from the lower region of the *Neobolus* beds of Kiura, natural size and enlarged.

Figs. 15—16. DISCINOLEPIS GRANULATA, Waagen.
Specimens from the lower region of the *Neobolus* beds of Kiura (fig. 15) and Intana (fig. 16), natural siae and enlarged.

Fig. 17. LINGULA (?) KIURENSIS, Waagen.
Specimen from the lower region of the *Neobolus* beds of Kiura, natural size and enlarged.

Fig. 18. LINGULA (?) WARTHI, Waagen.
Specimen from the lower region of the *Neobolus* beds of Kiura, natural size and enlarged.

Fig. 19. FENESTELLA (?) sp.
Specimen from the lower region of the *Neobolus* beds of Kiura, natural size.
(The figures 3 to 19 are repeated from Vol. I, Pl. LXXXIV, LXXXV, LXXXVI and XCI of the present work, in order to give here a complete illustration of the Cambrian fauna of the Salt-range.)

1b 1a 1c 2b 2a 2c

2d 2e

3b 3c 4c 4b

3a 8c 7. 9c 4a

5. 9a

8b 9b

8a 10a 10b 11b 11a 6a

12c

12b 12a 13b 13a 14b 14a 6b

15a 16a 19. 17a 18a

15b 16b 17b 18b

A. Swoboda del. et lith

Joh. Haupt print.

PLATE III.

SPECKLED SANDSTONE.

BOULDER-BEDS.

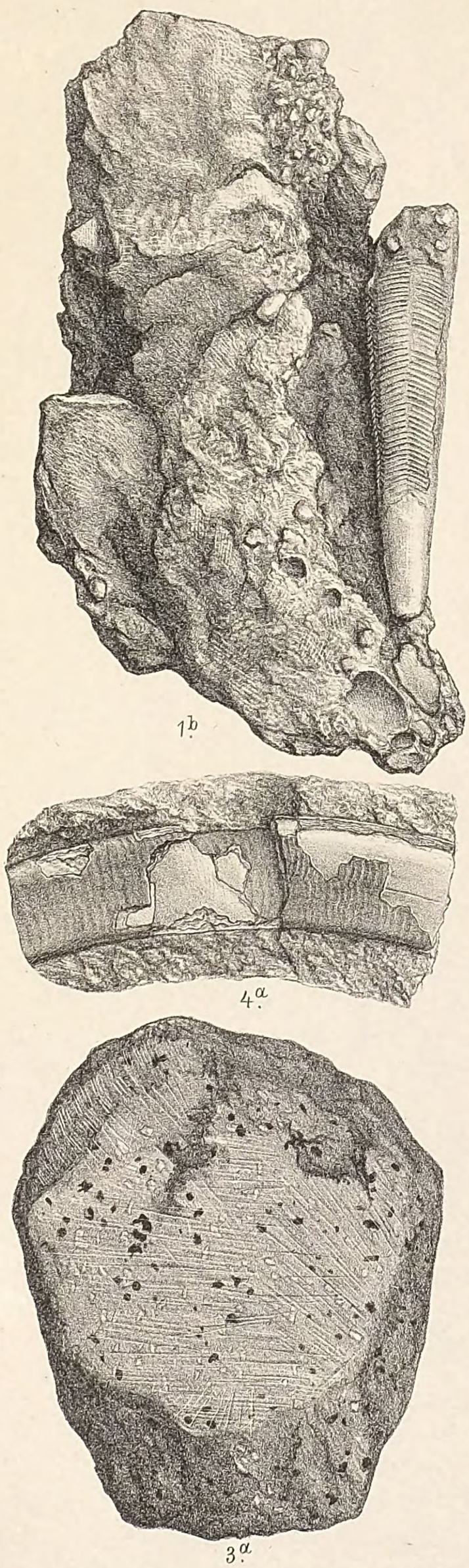
Fig. 1. Piece of conglomerate enclosing a "rolled" specimen of CONULARIA LÆVIGATA, see page 124. The specimen is from Chél hill; the *Conularia* shows its sculpture preserved on the lateral face and on the face adherent to the rock. 1*a*, 1*b*, two aspects from different sides.

Fig. 2. Piece of conglomerate with two nodules, one containing a *Conularia*, the other without a fossil, from Chél hill, page 124. 2*a*, 2*b*, two aspects from opposite sides.

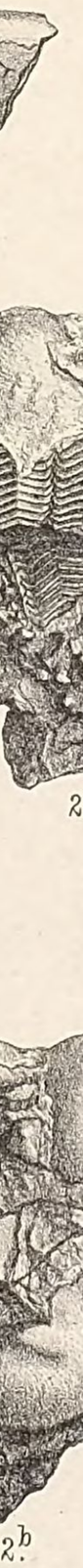
Fig. 3. Ice-scratched pebble of porphyry from the boulder-bed of Chél hill, page 148. 3*a*, 3*b*, two different aspects from opposite sides.

Fig. 4. SERPULITES UNDULATUS, Waagen, n. sp., page 135.
Compressed specimen contained in a nodule from Dillur. 4*a*, one-half of the nodule; 4*b*, the opposite half of the same.

Figs. 5 and 6. SERPULITES WARTHI, Waagen, page 135. Two specimens from the boulder-bed of Chél hill. Fig. 5, view from above (from the narrow side). Fig. 6*a*, *b*, lateral view and transverse section of another specimen.



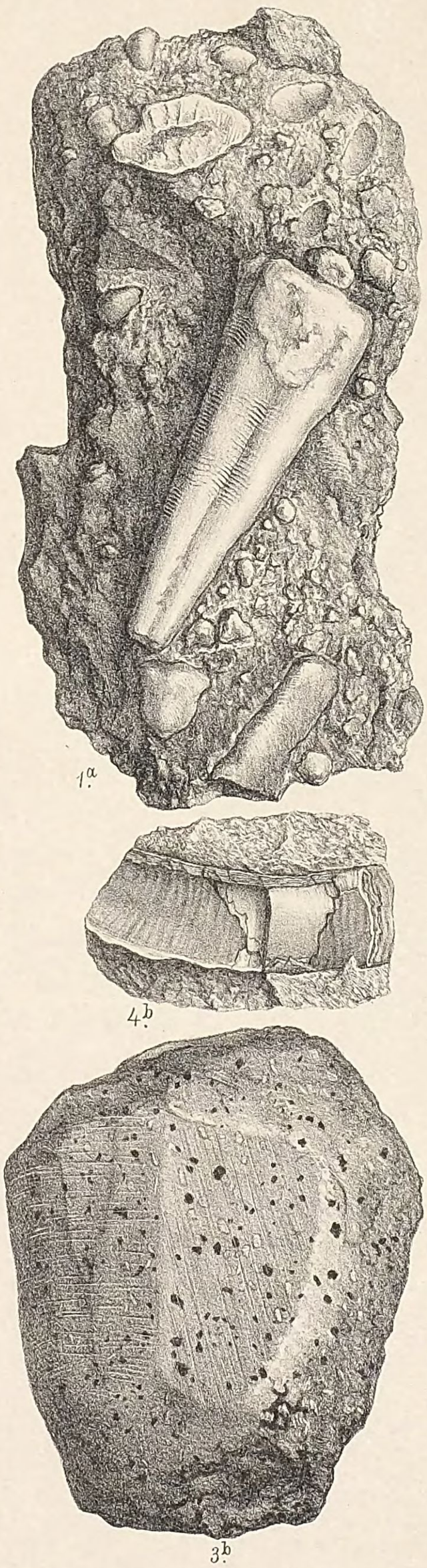
1b.



5.



6a. 6b.



1a.

4a.



2a.

4b.

3a.



2b.

3b.

A. Swoboda del. et lith. Joh. Haupt print

PLATE IV.

SPECKLED SANDSTONE.

BOULDER-BEDS.

Fig. 1. BUCANIA WARTHI, Waagen, n. sp., page 121.
Best preserved specimen from Chél hill; 1*a*, *b*, lateral and frontal views, natural size; 1*c*, *f*, side, front, back and top views, enlarged.

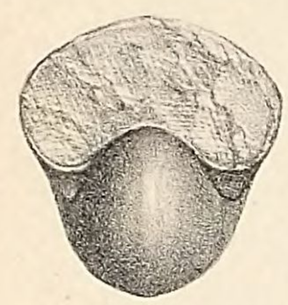
„ 2. BUCANIA WARTHI, Waagen, n. sp., page 121.
Internal cast from Dillur; side, front and back views, natural size.

„ 3. BUCANIA WARTHI, Waagen, n. sp., page 121.
Small specimen, with well-preserved shell from Chél hill; back view, enlarged.

„ 4. PLEUROTOMARIA NUDA, Dana, page 120.
Specimen without shell from the boulder-bed of Dillur; front, back and basal views, natural size.

„ 5. CONULARIA LÆVIGATA, Morris, page 123.
Large well-preserved specimen from the boulder-bed of Chél hill; 5*a*, *b*, *c*, different views, natural size; 5*d*, *e*, *f*, different parts of the surface, enlarged; 5*g*, transverse section, natural size.

„ 6. CONULARIA WARTHI, Waagen, n. sp., page 126.
Large, well-preserved specimen from the boulder-bed at Chél hill; 6*a*, *b*, frontal and lateral views, natural size; 6*c*, *d*, parts of the surface, enlarged; 6*e* transverse section, natural size.


1d.


1b.


1c.


1a.


1e.


3.


2c.


2a.

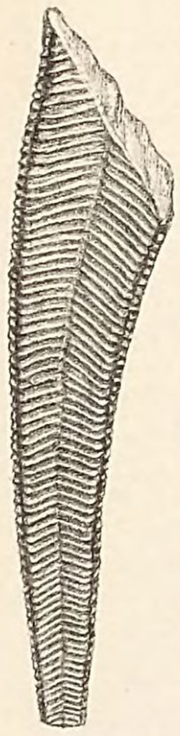

2b.


1f.


4b.


4c.


4a.


5b.

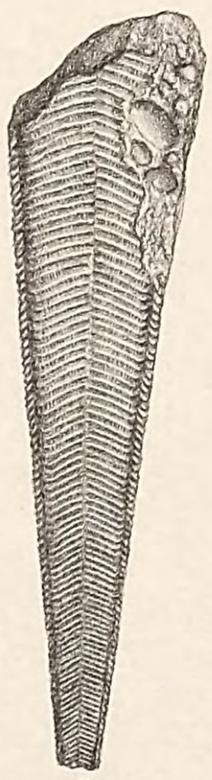
5d.

5c.

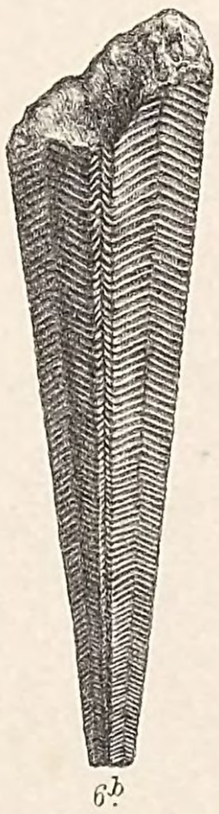

5e.


5a.


6c.


6a.


6d.


6b.


5f.

6e.


5g.

A. Swoboda del. et lith.

Joh. Haupt print

PLATE V.

SPECKLED SANDSTONE.

BOULDER-BEDS.

Fig. 1. CONULARIA WARTHI, Waagen, n. sp., p. 126.
Fragmentary specimen with exceptionally closely set ribs from the boulder-bed of Dillur; 1*a*, natural size; 1*b*, part of the surface, enlarged. (See also Pl. IV, fig. 6).

" 2. CONULARIA TENUISTRIATA, M'Coy, p. 125.
Fragmentary specimen from Chél hill; 2*a*, natural size; 2*b*, part of the surface, enlarged; 2*c*, transverse section, natural size.

" 3. CONULARIA TENUISTRIATA, M'Coy, p. 125.
Fragmentary specimen from Dillur; 3*a*, natural size; 3*b*, *c*, parts of the surface enlarged; 3*d*, transverse section, natural size.

" 4. SANGUINOLITES *cf.* MITCHELLI, Koninck, p. 127.
Fragmentary specimen from Dillur; 4*a*, lateral view, 4*b*, front view, 4*c*, top view, all natural size.

" 5. NUCULA SP. INDET., page 129.
Specimen from Chél hill; 5*a*, natural size; 5*b*, enlarged; 5*c*, front view.

" 6. SANGUINOLITES TENISONI, Kon., p. 128.
Young specimen from Chél hill; 6*a*, *b*, lateral and front views, natural size; 6*c*, lateral view, enlarged.

" 7. PSEUDOMONOTIS SUBRADIALIS, Waagen, n. sp., p. 129.
Small specimen from Dillur; 7*a*, natural size; 7*b*, *c*, different views, enlarged.

" 8. AVICULOPECTEN *cf.* LIMÆFORMIS, Morris, p. 130.
Fragmentary specimen from Dillur, natural size.

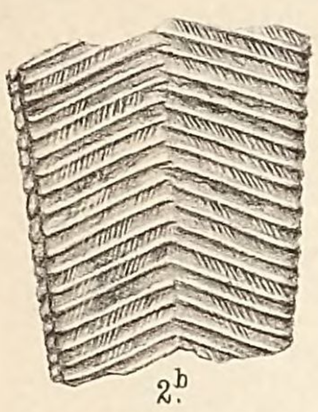
" 9. MARTINIOPSIS DARWINI, Morris, p. 131.
Young specimen, dorsal valve, from Dillur; 9*a*, *b*, natural size; 9*c*, enlarged.

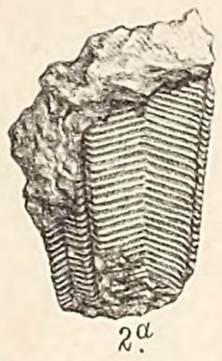
" 10. SPIRIFER VESPERTILIO, Sow., p. 130.
Specimen of the dorsal valve, external cast, out of a greyish-brown sandstone, not found *in situ*, near Dillur. It is therefore doubtful whether the fossil should not better be counted with the fossils out of the "Olive beds;" 10*a*, *b*, *c*, different views, natural size.

" 11. DISCINA SP. INDET., p. 133.
Fragmentary specimen showing both valves, preserving parts of the shell; from Dillur, natural size.

Figs. 12—15. DISCINISCA WARTHI, Waagen, n. sp., p. 134.
Four different specimens from Chèl hill (12-13) and Dillur (14-15); 12, under valve from the interior side, showing the perforation; 12*a*, natural size; 12*b*, enlarged. 13, specimens showing parts of the upper and the interior side of the lower valve; 13*a*, natural size; 13*b*, enlarged. 14 and 15, upper valves, the largest specimens known to me, natural size.

Fig. 16. SERPULITES TUBA, Waagen, p. 136.
Fragmentary specimen from Dillur; 16*a*, natural size, 16*b*, enlarged.


2b.


2a.


1a.


1b.


3a.


3b.


4a.


2c.

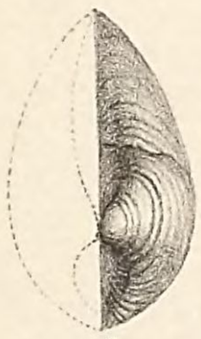

3c.


3d.


6c.


6b.


4b.


4c.


5a.


5b.


5c.


6a.

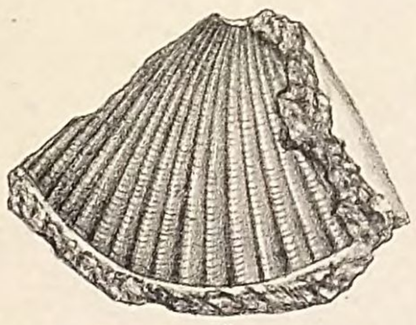

7b.

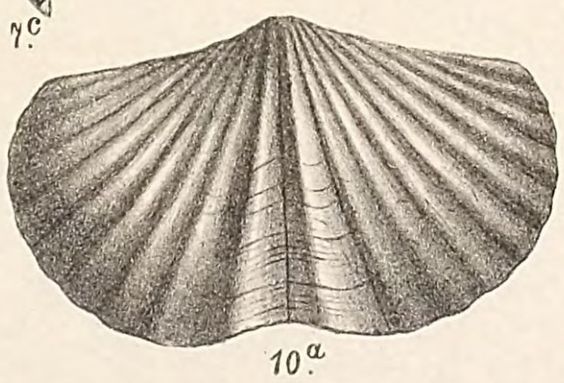

7a.

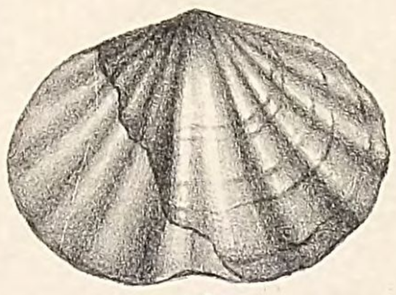

7c.


9b.


9a.

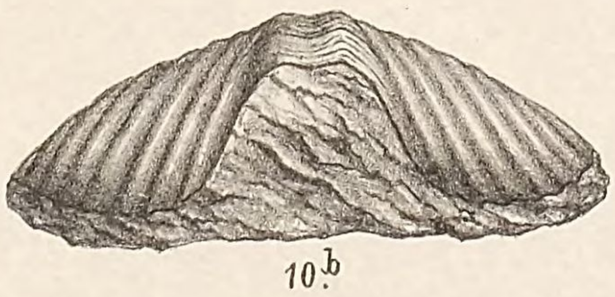

8.


10a.


9c.


10c.


16b.


10b.


16a.


11.


15.


14.


12b.


13b.


13a.


12a.

A. Swoboda del. et lith.

Joh. Haupt print.

PLATE VI.

SPECKLED SANDSTONE.

OLIVE-BEDS.

Figs. 1-4. EURYDESMA GLOBOSUM, Dana, p. 138.

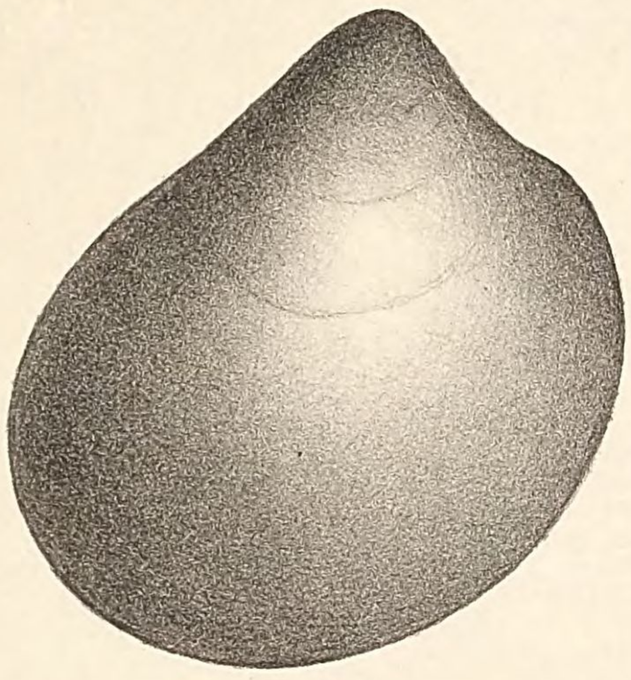
Fig. 1. Specimen of the left valve from Sadowal: 1, lateral view, 1*a*, front view, 1*b*, back view. Fig. 2, other fragmentary specimen of the left valve from Sadowal, the shell preserved only in the apical region; 2, lateral view, 2*a*, front view, 2*b*, back view, 2*c*, the hinge badly preserved. Fig 3, hinge of the left valve much broken. Fig. 4, hinge of the left valve of another specimen: *a*, wing-like expansion fitting into the blunt tooth of the right valve, *b*, ridge-like hinge teeth (?), *c*, ligamental furrow (see also Pl. VIII, fig. 2).

Figs. 5 and 6. EURYDESMA ELLIPTICUM, Dana, p. 141.

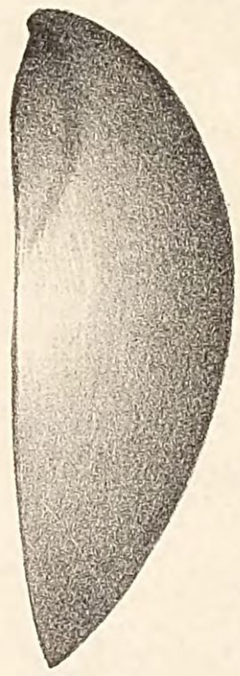
Fragmentary specimens of the hinge of the right valve from Sadowal. Fig. 5*d*, blunt spoon-shaped tooth; *e*, prominence fitting into an excavation of the wing-like expansion of the other valve; *c*, ridge-like hinge tooth; *g*, groove for the reception of the ridge-like tooth of the other valve; *h*, byssal furrow; *i*, ligamental furrow. Fig. 6, other fragment showing the hinge of the right valve.



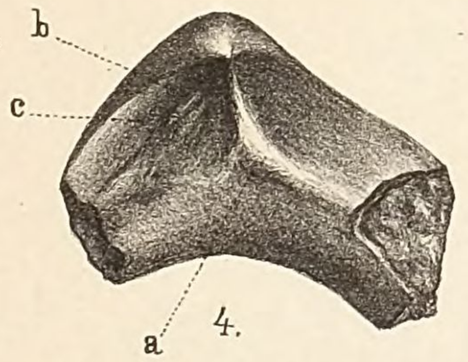
1.b



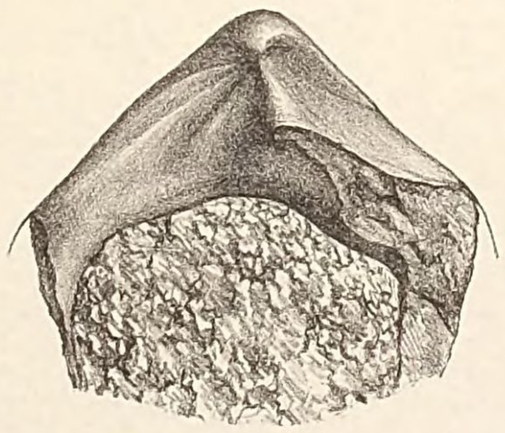
1.



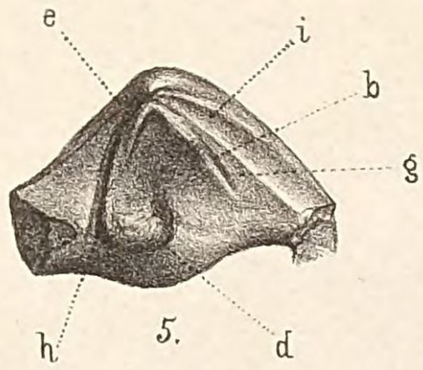
1.a



4.



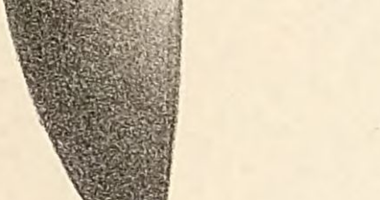
3.



5.



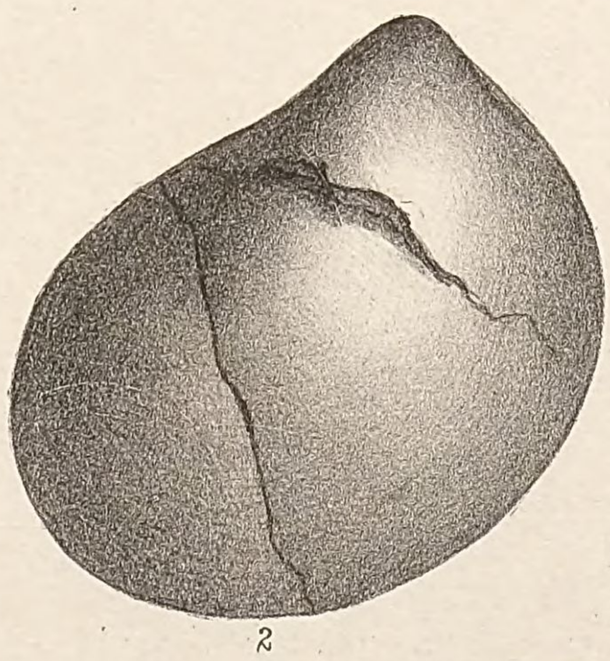
6.



2.c



2.b



2



2.a

A. Swoboda del. et lith.

Joh. Haupt print.

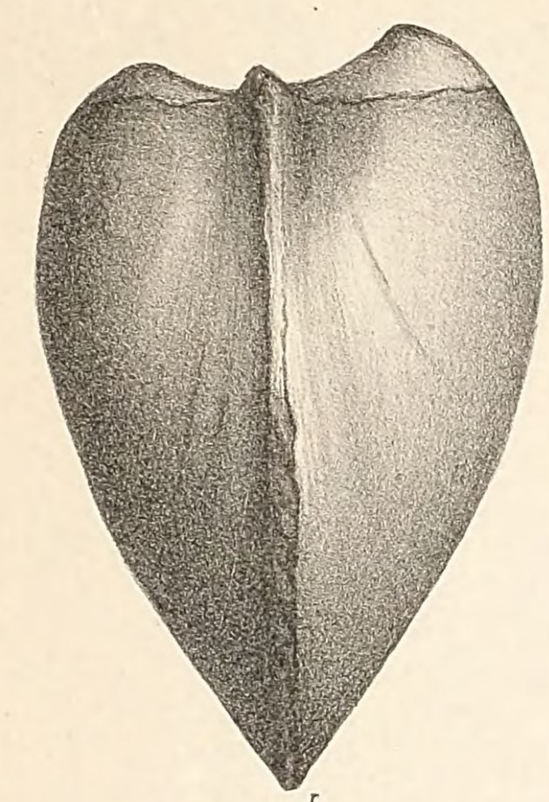
PLATE VII.

SPECKLED SANDSTONE.

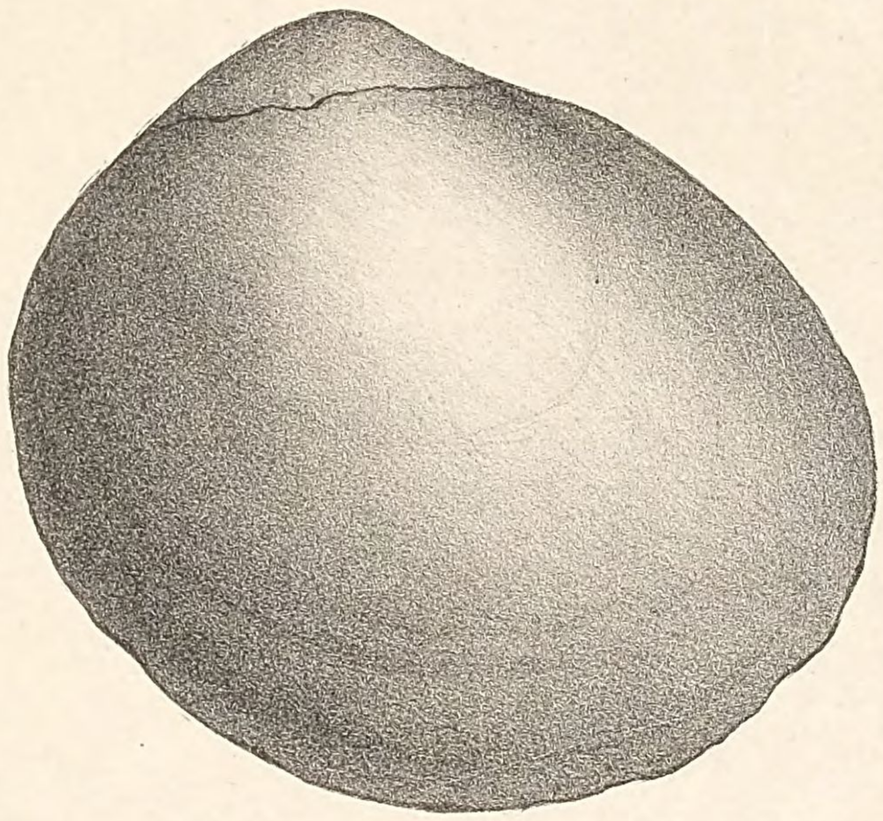
OLIVE-BEDS.

Figs. 1, 2. EURYDESMA ELLIPTICUM, Dana, p. 141.

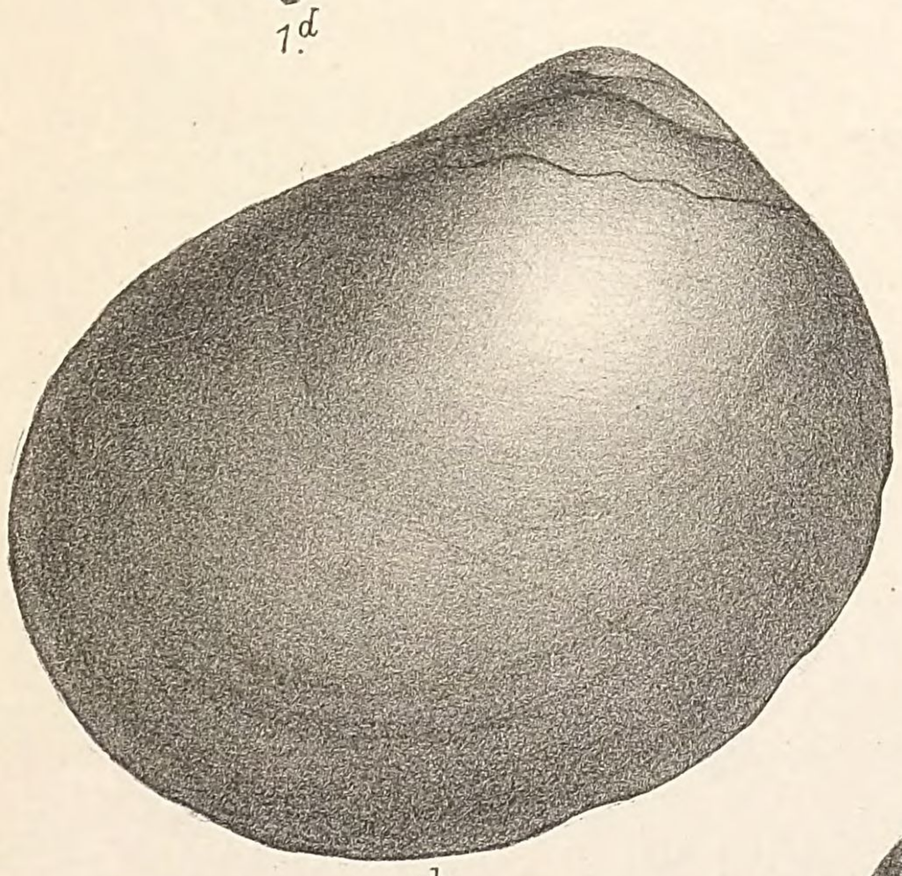
Fig. 1. Specimen, internal cast, from Dandote: 1*a*, large or right valve, 1*b*, smaller or left valve, 1*c*, front view, 1*d*, back view, 1*e*, view from the hinge. Fig. 2, specimen of the right valve with preserved shell from Sadowal: 2*a*, lateral view, 2*b*, back view.



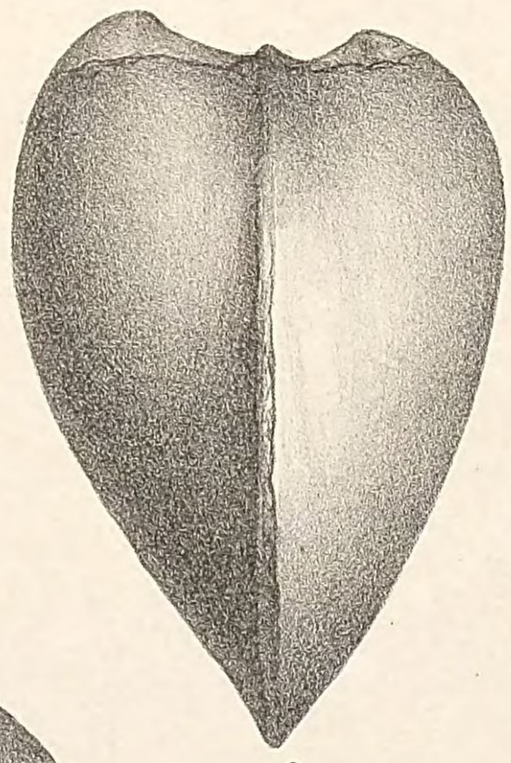
1.d



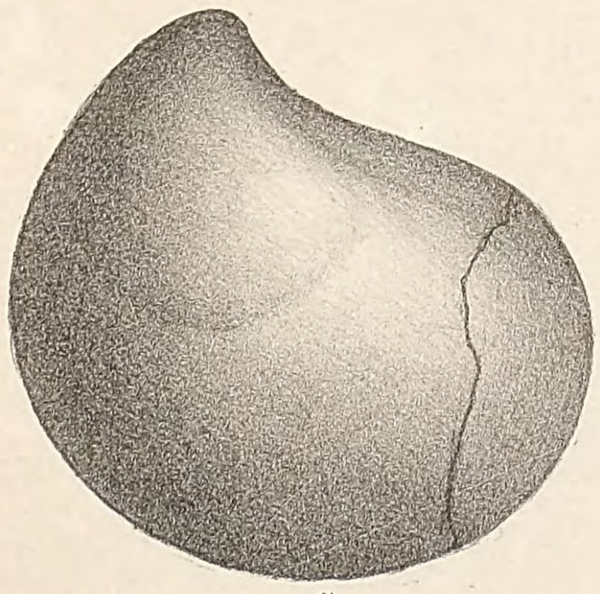
1.a



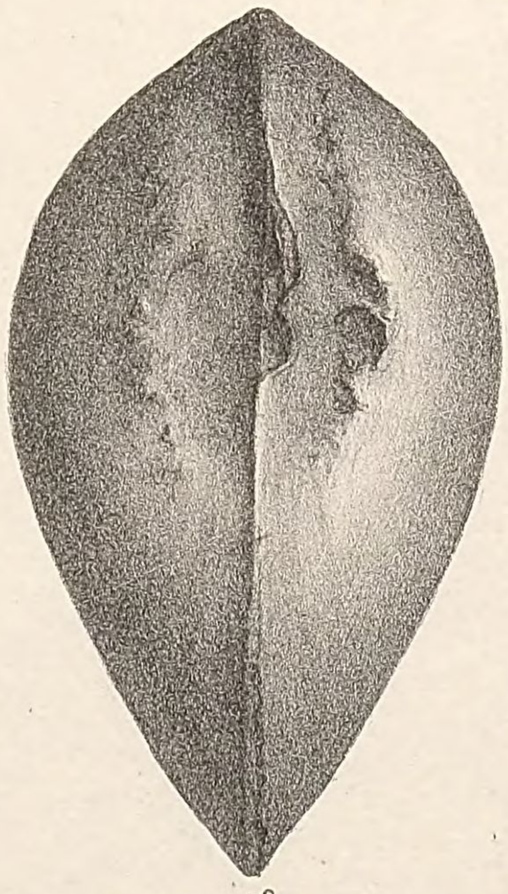
1.b



1.c



2.a



1.e



2.b

A. Swoboda del. et lith.

Joh. Haupt print.

PLATE VIII.

SPECKLED SANDSTONE.

OLIVE-BEDS.

Figs. 1–2. EURYDESMA ELLIPTICUM, Dana, p. 141.

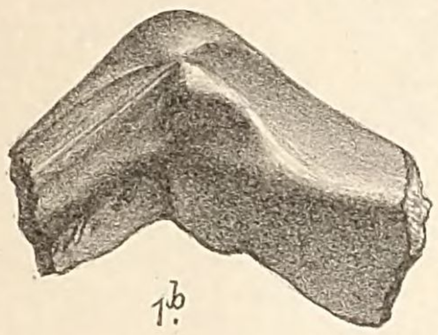
Fig 1. Fragmentary specimen from Sadowal: 1*a*, internal cast of the left valve showing the large posterior muscular impression and the numerous deep and small ones, forming a broken line extending towards the front, and the impression of part of the hinge: 1*c*, apical region of the shell, taken away from the same specimen and showing the hinge of the left valve. Fig. 2, the preceding specimen and the one represented in Pl. VI, fig. 5, fitted together to show the two valves united; *h*, byssal fissure, and prominence of the right valve fitting below the apex of the left one.

Figs. 3—4. EURYDESMA CORDATUM, Morris, p. 142.

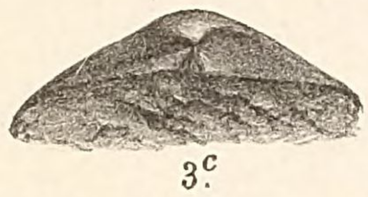
Fig. 3. Young specimen from Sadowal; left valve, 3*a*, lateral view; 3*b*, back view; 3*c*, hinge, badly preserved. Fig. 4, internal cast of a small specimen from Dandote; 4*a*, view from the left side; 4*b*, anterior view; 4*c*, posterior view; the muscular impressions are drawn too distinctly with the exception of the small intermediate ones.

Fig. 5. (?) MÆONIA GRACILIS, Dana, p. 143.

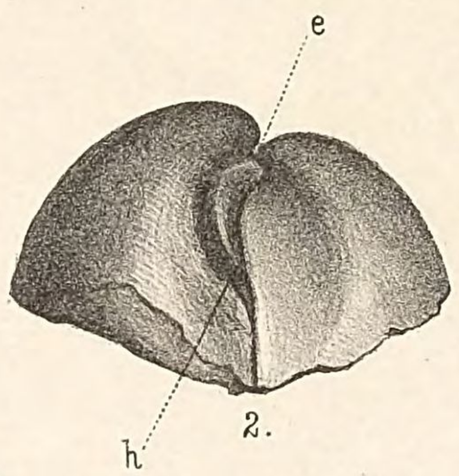
Specimen of the right valve with preserved shell, but badly weathered, from Sadowal: 5*a*, lateral view, 5*b*, view from the hinge margin.



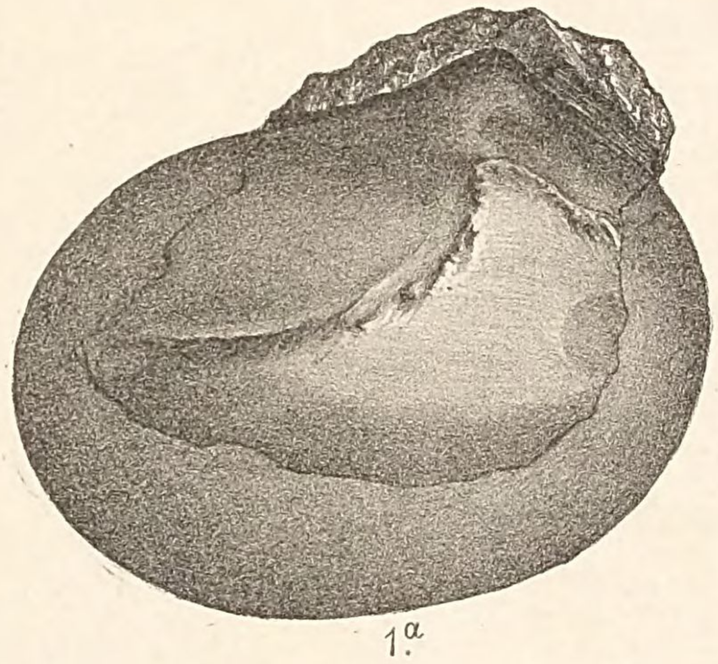
1.b



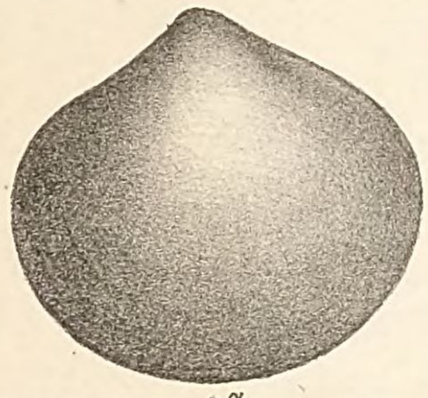
3.c



2.



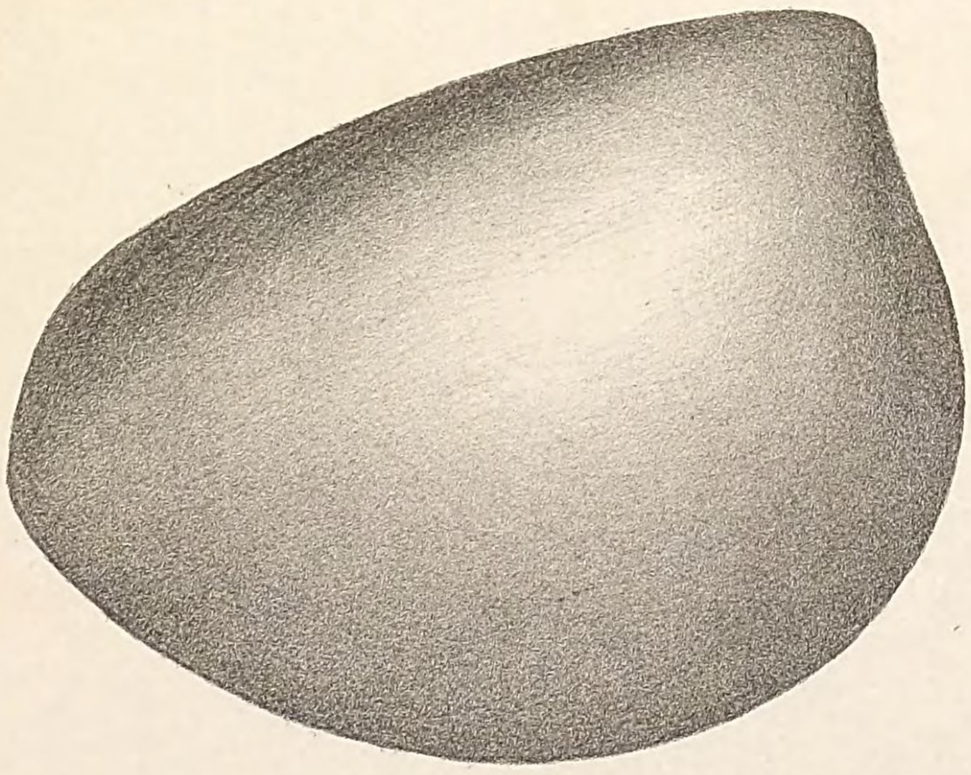
1.a



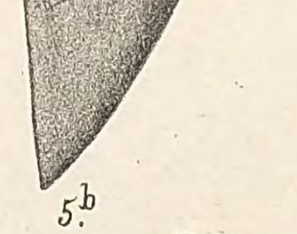
3.a



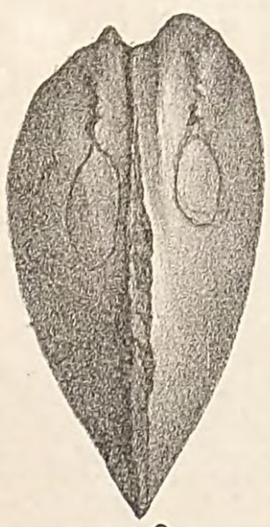
3.b



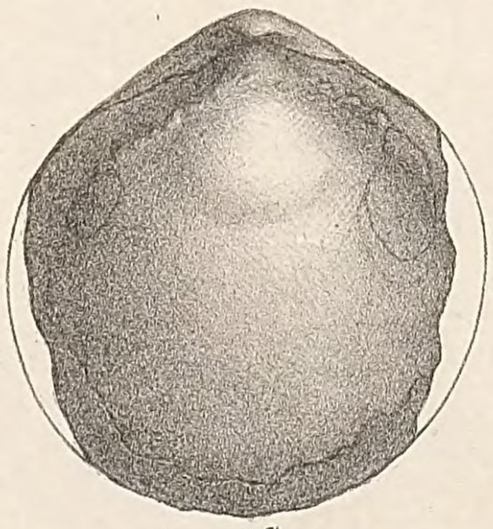
5.a



5.b



4.c



4.a



4.b

A. Swoboda del. et lith.

Joh. Haupt print.

PALÆONTOLOGIA INDICA.

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„ II, pp. xv, 363, pls. 45. 1881—84. Pt. 1: Siwalik Rhinocerotidæ. Pt. 2: Supplement to Siwalik and Narbada Proboscidia. Pt. 3: Siwalik and Narbada Equidæ. Pt. 4 Siwalik Camelopardalidæ. Pt. 5: Siwalik Selenodont Suina. Pt. 6: Siwalik and Narbada Carnivora.
„ III, pp. xxiv, 264, pls. 37 (1884—86). Pt. 1: Additional Siwalik Perissodactyla and Proboscidia. Pt. 2: Siwalik and Narbada Bunodont Suina. Pt. 3: Rodents and new Ruminants from the Siwaliks. Pt. 4: Siwalik Birds. Pt. 5: Mastodon teeth from Perim Island. Pt. 6: Siwalik and Narbada Chelonia. Pt. 7: Siwalik Crocodilia, Lacertilia and Ophidia. Pt. 8: Tertiary Fishes.
„ IV, Pt. 1 (1886). Siwalik Mammalia (Supplement 1), pp. 18, pls 6. Pt. 2: (1886). The Fauna of the Karnul caves: (and addendum to pt. 1); pp. 40 (19—58), pls. 5 (vii—xi). Pt. 3: (1887). Eocene Chelonia from the Salt Range: pp. 8 (59—66), pls. 2 (xii-xiii).

(SERIES VII, XIV.)

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(SERIES XIII.)

SALT-RANGE FOSSILS, *by* WILLIAM WAAGEN, Ph.D.

VOL. I. Productus-Limestone Group: 1 (1879). Pisces, Cephalopoda, pp. 72, pls. 6.
„ „ 2 (1880). Gasteropoda and supplement to pt. I, pp. 111 (73—183), pls. 10 (vii—xvi); (1 double).
„ „ 3 (1881). Pelecypoda, pp. 144 (185—328), pls. 8 (xvii—xxiv).
„ „ 4 (1882—85). Brachiopoda, pp. 442 (329—770), pls. 62 (xxv—lxxxvi).
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